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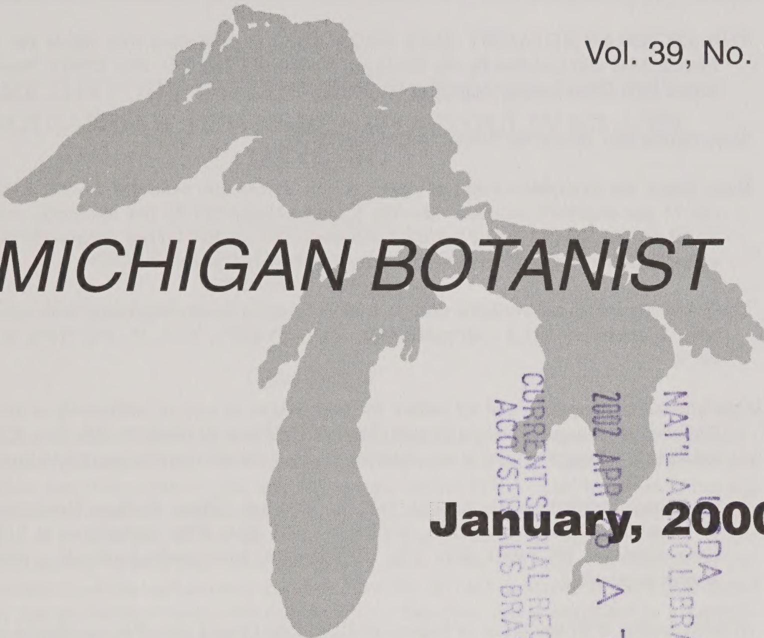

THE MICHIGAN BOTANIST

January, 2000

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Articles dealing with any phase of botany relating to the Great Lakes Region may be sent to the Editor at the address above. In preparing manuscripts, authors are requested to follow our style and suggestions in "Information for Authors": (volume 28, p. 43; volume 29, p. 143), **except** please omit all abbreviations in journal and book titles. Smaller contributions not involving illustrations may be submitted as e-mail attachments (indicate format, preferably WordPerfect, DOS or Windows) or incorporated into the body of an e-mail.

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FIRE HISTORY OF THE BUR OAK SAVANNAS OF SHEGUIANDAH TOWNSHIP, MANITOULIN ISLAND, ONTARIO

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ABSTRACT

The fire history of the bur oak savannas of Manitoulin Island, a globally rare vegetation community, was examined in Sheguiandah Township from the notes of two early land surveys (1864 and 1866) done before and after a catastrophic and widespread fire in 1865. Current locations of bur oak savanna were also surveyed and documented. Most current savannas match up with sites that were hardwood forest, at least in part, before the 1865 fire. All current savannas burned in 1865. A few current savannas already existed and some had burned, prior to the 1865 fire. No correlation was found between burn intensity and savanna creation. The fire of 1865 is shown to have maintained some savannas and probably to have created most others; therefore, fire is suggested as a management tool to maintain the openness of this vegetation type.
Key Words: alvar, vegetation history, early land surveys, Manitoulin Island, savanna creation

INTRODUCTION

The bur oak savannas of Manitoulin Island, Ontario, Canada (45°50′N, 81°55′W) are a globally and provincially rare vegetation community (Reschke et al., 1999; Bakowsky, 1997) tentatively ranked G1?S1S2 (Bakowsky, pers. comm. 2000). They feature scattered trees of *Quercus macrocarpa* Michx. (bur oak) over-topping a grass- or shrub-dominated groundlayer (Figure 1). The community differs from typical oak savannas, found further south and west, in having extremely shallow soils (0–20 cm) over horizontal limestone or dolostone bedrock, and in suffering seasonal drought stress during July and August.

Typical bur oak savannas on Manitoulin Island also differ from those elsewhere in having an alvar-like species composition, and many in fact consider these savannas to be a type of alvar (Bakowsky, pers. comm., 2000; Brownell, 2000). Shrubs such as *Viburnum rafinesquianum* Schultes, *Amelanchier spicata* (Lam.) K. Koch, *Rhus aromatica* Aiton, and *Symphoricarpos albus* (L.) S. F. Blake are typical, while the herbaceous layer is usually dominated by *Danthonia spicata* (L.) P. Beauv., with *Cerastium arvense* L., *Geum triflorum* Pursh, *Ranunculus fascicularis* Muhl., and *Senecio pauperculus* Michx. common. Uncommon species of the Sheguiandah savannas which show the vegetation's prairie affinities include *Astragalus neglectus* (Torr. & A. Gray) Sheldon, *Penstemon hirsutus* (L.) Willd., *Potentilla arguta* Pursh, and *Coreopsis lanceolata* L. In addition, the moth *Zale calycanthata* is known in Canada only from bur oak sites on Manitoulin Island (J.K. Morton, pers. comm., 2000).

FIGURE 1. An example of bur oak savanna in Sheguiandah Township. At this site, common juniper is the dominant understory shrub. At other sites this stratum may be dominated by other species, especially *Viburnum rafinesquianum* or *Amelanchier spicata*.

All of these oak savanna sites are presently used as livestock pasture, or have been used as such in the recent past. Grazing introduces weed species and soil disturbance, and causes a slow degradation of the diversity of native vascular plant species in the community (Reschke et al. 1999; Jones, unpublished data). With the recent recognition of the rarity of this vegetation type, protection and management of these bur oak savannas will be issues of concern in the near future. Fire is known to be involved in the maintenance of bur oak savannas elsewhere (Tester, 1996); therefore, the fire history of the Manitoulin bur oak savannas was investigated to see whether fire was involved in their origin and whether controlled burning should be looked into as a possible management tool.

Sheguiandah Township, on Manitoulin Island (Figure 2), is uniquely placed for such a study. The township was originally surveyed in 1863–64 (McPhillips, 1864) to lay out the location of lots and roads before the island was opened to settlers. In 1865 a catastrophic fire burned most of the township, destroying all but eighteen of the survey markers; consequently, the township had to be surveyed again. A second survey was done in 1866 (O'Keefe, 1866).

As the surveyors cleared the lines they were laying out, they noted facets of the land—usually dominant tree species, sometimes with the addition of soil or landform characteristics—along accurately measured sections of the surveyed lines. The information was intended to help settlers choose property site-unseen and to help in recognition of the property upon arrival. Consequently, sufficient

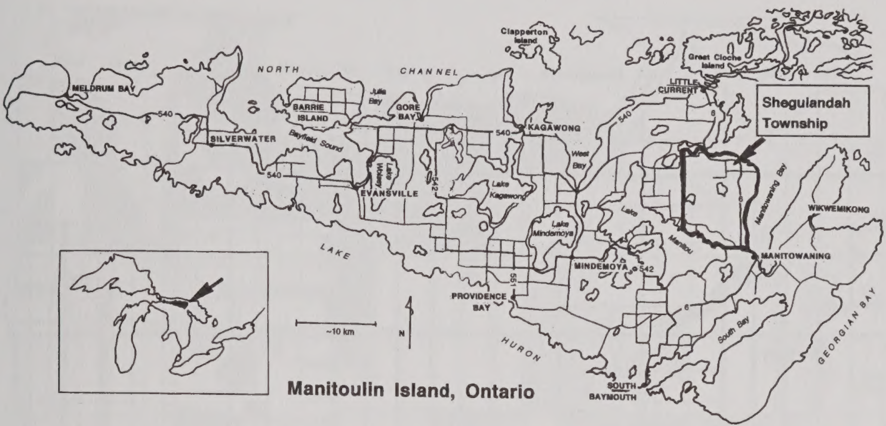

FIGURE 2. Location of Sheguiandah Township on Manitoulin Island, and location of Manitoulin Island (inset) in the Great Lakes region.

information exists from this survey grid to construct vegetation maps of Sheguiandah Township before and after the catastrophic fire.

METHODS

Current occurrences of bur oak savanna were field surveyed in Sheguiandah Township in 1997 (Figure 3). The vegetation of the township before the fire (and prior to settlement) was mapped from notes of the survey of 1863–64 (Figure 4). The post-fire vegetation was mapped based on the notes of the survey of 1866 (Figure 5).

This type of mapping process has some inherent error since the surveyors did not see the interior of each lot. In this study it was assumed that the recorded vegetation extended to the back of each lot, unless the surveyor indicated otherwise or topography such as a cliff precluded it. Double or heavy lines on the maps show the actual paths the surveyors walked. Accuracy of interpretation is highest where double lines intersect, and lowest in the interior of the rectangles their paths form. Accuracy is higher in open areas, such as those created by burning, because the surveyors' line of sight extended farther.

Comparisons were made to see how many current bur oak sites burned in 1865 and what type of vegetation they were prior to the fire. In addition, the diaries and letters of the surveyors were examined for any further clues about oak savanna origins.

The intensity of burning at each site was interpreted from the notes. O'Keefe frequently uses the term "clear burning" to indicate a lot that had burned so completely that homesteaders could consider it cleared. For the purpose of this study, clear burning was assumed to indicate high intensity burning because it shows much of the timber was consumed by the fire. The surveyor describes many other sites simply as "burnt," "burnt woods," "windfall, burnt," etc. These comments were interpreted to mean an intermediate (and typical) level of burning. Lot descriptions that have no direct mention of burning, but where O'Keefe notes the corner posts or bearing trees burned down, are interpreted to be areas of lighter burning (see dots on Figure 4).

Finally, cross sections ("cookies") were taken from stumps of 5 bur oak trees recently cut by landowners for firewood at one site. Tree ages were determined from growth ring-counts to try to estimate the dates of savanna establishment.

FIGURE 3. Locations of bur oak savanna study sites field surveyed in 1997.

FIGURE 4. Pre-fire distribution of hardwoods, windfall and burning based on the survey of 1863–64 (McPhillips, 1864) compared with current bur oak savanna study sites. Rectangles shown are hundred acre lots. Double lines are road allowances walked by the surveyors.

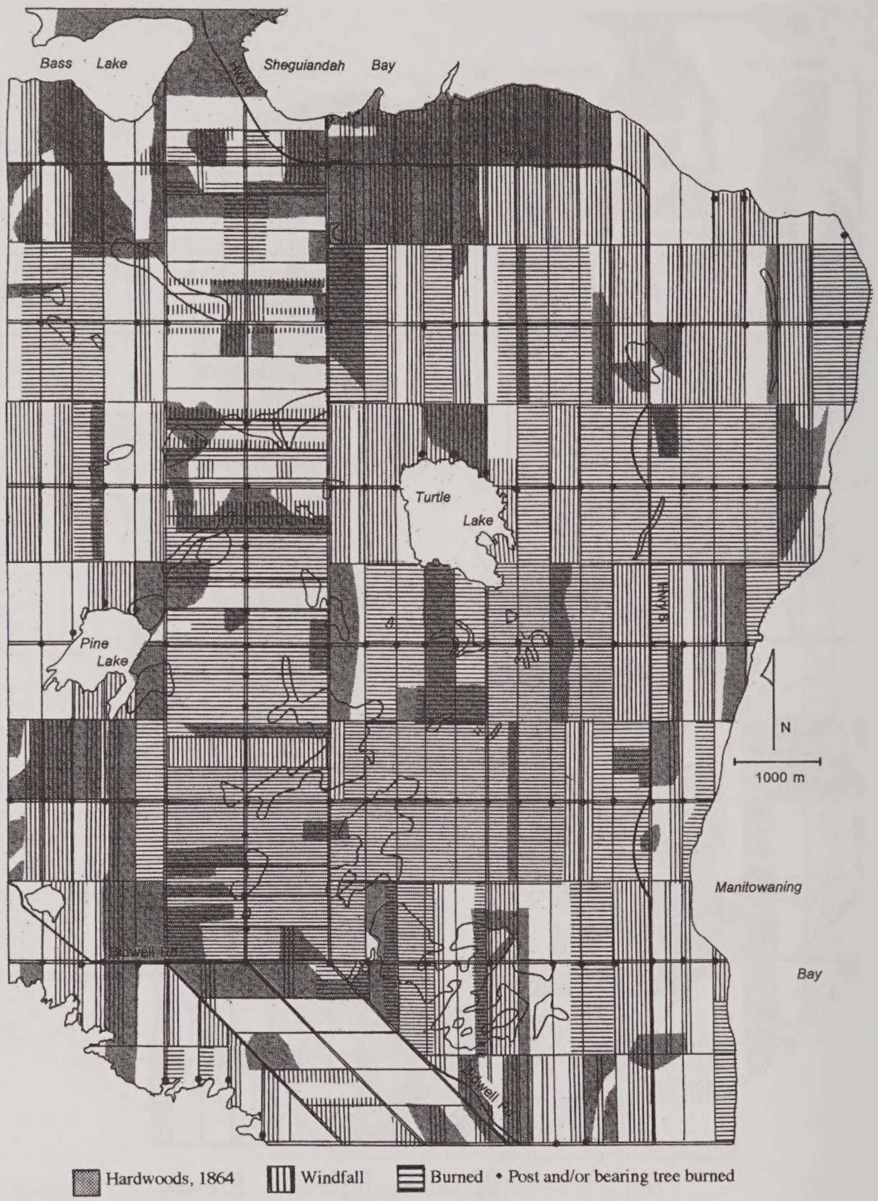

FIGURE 5. Location of windfall and burning in 1866 (O'Keefe, 1866), superimposed on 1863–64 hardwood distribution and current bur oak savanna study sites. Dots indicate corners where the surveyor specifically notes that posts or bearing trees burned. The lack of a dot does not indication a lack of burning since the surveyor did not always indicate if he found the old post.

RESULTS

Table 1 gives a comparison of the descriptions of current oak savanna locations before and after the fire of 1865 (italics are direct quotes). Table 2 summarizes the comparison.

Comparisons of the current locations of savannas to pre-fire vegetation show that most bur oak savannas were hardwood stands, at least in part, before the fire of 1865. Seventeen of 27 sites were listed as hardwoods, at least in part, and an additional 2 sites included maple or basswood (hardwood species) in the lot description. Three sites were windfall only, and while there is no indication of species here, the first surveyor McPhillips (1864), notes in his cover letter to his superior that "Some windfalls were originally hardwood but the young timber growing up is now poplar, birch, tamarack and spruce." On the other hand, before the fire some 4000 acres of the township were described as windfall, and it is unlikely that all of it was formerly hardwoods. A further 4 sites (nos. 4, 5, 6 and 12) had no indication of hardwoods at all but were listed as swamps or mixed woods.

Bearing tree notations and lists of dominant species show "hardwoods" were composed of maple, basswood, red oak, ironwood, "oak" (not identified to species), and elm in various combinations. The occasional cedar or balsam fir was also sometimes present, but usually when these species had a significant presence the surveyors recorded a species list such as "cedar balsam maple." Pine is rarely mentioned in connection with the term hardwoods, although it is frequently listed with other coniferous species. Thus, "hardwoods" indicates a forest composed almost entirely of deciduous trees. It is possible bur oak was present, but it is never mentioned directly.

Some bur oak savanna existed prior to the fire of 1865. One site was listed in the first survey as "stunted oaks," while a second site, listed as "a few trees of hardwood," was also probably a savanna. In addition, in his cover letter McPhillips describes a rocky area at the top of a steep slope (a cliff) with shallow soil and "a girdle of small stunted hardwoods running the same direction as the edge of the rocks." This perfectly describes at least two of the bur oak savannas that exist today which exist as narrow bands along the edge of cliffs.

As expected, all locations of current bur oak savannas burned to some degree in the 1865 fire. However, current savanna occurrence does not correlate with any particular level of burning. Ages determined from growth-ring counts (made in 1996) on bur oaks varied widely, ranging from 71–115 years. These are minimum ages since the counts were done above the base of the tree. The ages put establishment of the oldest tree sampled somewhere around 16 years after the fire. More interestingly, increasing diameter of trees did not correlate with age, showing that very local stresses which can inhibit growth occur in these shallow-soil sites. Therefore, size does not make it immediately apparent which trees are the oldest.

TABLE 1. 1864 and 1866 descriptions of current bur oak savanna locations (direct quotes are in italics).

Site # and Location	1863–64 description	1866 description	Interpretation
Site1 Lot 11, Con. 12	Hardwoods—no mention of windfall;	Windfall, hardwoods	Light burning assumed from new windfall and clear burning on adjacent lot.
Site 2 Lots 4+5, Con. 11 Lots 26+27, Con. B	Hardwoods in rear Lot 5 and junction Lots 26–27 Swamp in some parts.	Windfall. Hardwood still standing Lots 26–27.	Light burning: posts burned.
Site 3 Lot 2, Con. 11	Swamp-hardwoods at western edge	*Burnt windfall, swamp*	Area is on plateau at edge of steep slope.
Site 4 Lot 2, Con. 10–11	Swamp	*Burnt windfall, swamp*	Currently rocky area in large, open pasture
Site 5 Lot 3, Con. 10	Swamp	*Burnt windfall, swamp*	Currently rocky area in large, open pasture
Site 6 Lots 22–23, Con. A–B	*Tamarack, poplar, stunted pine; cedar, black ash, balsam*	*Scattered windfall, partly burnt*	Does not appear to have been hardwoods.
Site 7 Lots 21–22, Con. B	Hardwoods on Lot 22;	*Windfall, burnt*; some hardwoods remained	
Site 8 Lots 3–4, Con. 9	Hardwoods in part; rocky outcrops	*Burnt woods, limestone rock,* mixed forest.	
Site 9 Lots 18–20, Con. B	Hardwoods on Lot 20	*Burnt woods, windfall;* part *maple, basswood, ironwood, birch*	Second surveyor indicates more hardwoods here than first
Site 10 Lots 4–5, Con. 7	*Good Hardwood,* Low land near lake	*Good hardwood*	Light burning: posts all burned
Site 11 Lot 4–5, Con. 6	*Good Hardwood*	*Good hardwood land*	Light burning: posts burned, bearing trees lived
Site 12 Lot 11, Cons. 8–9	*Swamp*; *cedar, poplar, birch, balsam*	*Scattered windfall*	Light burning, posts burned. Current site is small.
Site 13 Lot 11, Con. 7 Lots 16–17, Con. A	*Good hardwood, rolling land, limestone covered with a few inches of Earth; burned windfall*	*Good land, woods** Bearing trees were maple.	Light burning: posts burned, bearing trees lived
Site 14 Lots 14–15, Cons. 6–7	*A few trees of hardwood* (prob. savanna). Windfall in part.	*Clear burning, good land**.	Intense burning
Site 15 Lots 16–17, Cons. 6–7	*Windfall, burned; Small brush*	*Clear burning, good land**	Intense burning
Site 16 Lot 11, Cons. 5–6 Lots 11, 13, 14, 15 Con A	Most was windfall; Hardwoods in part; Some *small brush* (may mean past burning)	*Woods and scattered windfall; clear burning; not much surface, little soil*	Large, heterogeneous area. Burn intensity varies

(Continued)

TABLE 1. Continued

Site # and Location	1863–64 description	1866 description	Interpretation
Site 17 Lot 14 Cons. 5–6	Hardwood and mixed forest	*Clear burning, good land*	Current site is small
Site 18 Lot 15–16, Con. 5	*Stunted cedar, small pine, balsam;* (*stunted oaks* =savanna? adjacent)	*Clear burning*	Current site is small
Site 19 Lots12–13 Con. 5 Lots 11–13 Con. 4 Lot 11, Con. 3	*Windfall and small brush* (shows past burning?)	*Clear burning, burnt windfall*	Current site is large area
Site 20 Lots 8–9, Cons A–B	*Dry cedar, maple, small pine*. Bearing trees were maple	*Clear burning*	
Site 21 Lots 12–13, Con. 3 Lots 12–14, Con. 2	*High hardwood* on half of site	*Scattered windfall. Good hardwood land* left in part. Some *clear burning*	Current site is large area. Burn intensity varies
Site 22 Lots 15–16 Con. 3 Lots 14–16, Con. 2	*Strip of hardwood* in mixed forest; *small hardwood timber, rocky land* (prob. savanna); hardwoods-east side	*Strip of hardwood; rocky land; windfall.* Posts and bearing trees burnt; good hardwoods remained at east side	Current site is large area. Burn intensity varies
Site 23 Lots 16–17, Con. 2	Hardwoods; *maple basswood, cedar, balsam*	Hardwoods; *maple, basswood, cedar, balsam, windfall, rocky*	Light burning: posts burned, bearing trees lived
Site 24 Lot 17, Con. 2	Hardwoods; *maple, basswood, cedar, balsam*	Hardwoods; *maple, basswood, cedar, balsam; all woods*	Light burning: posts burned, bearing trees lived Strip of hardwood at edge of field
Site 25 Lots 20–21, Con. 8	*Windfall*	*Clear burning*	
Site 26 Lots 20–21, Con. 10	Mixed forest: bass-woodindicates some hardwood present	*All very bad windfall; cedar, birch, basswood*	Light burning: posts and bearing trees burned
Site 27 Lot 24, Cons. 10–11	Hardwoods; *maple, basswood and poplar*	*Very bad windfall; maple, basswood and poplar*	Light burning: posts and bearing trees burned. Strip of hardwoods along edge of cliff.

*Usually meant either usable or marketable timber or cleared land desirable for homesteading.

DISCUSSION

Some lots were hardwoods only in part prior to the fire. Yet, it is clear that the presence of hardwood is what is important. Non-hardwood vegetation existed extensively throughout the township, yet savanna formed at only 4 locations where no hardwood was listed (sites 4, 5, 6, and 12). Furthermore, bur oak is an occasional component of some hardwood forests on Manitoulin Island today

TABLE 2. A summary of the changes in vegetation at current bur oak savanna sites, before and after the fire of 1865.

1864 description; of 27 current bur oak savanna sites:
- 19 were hardwoods in part (3 had trees scattered, small or in a band)
- 3 were windfall*
- 3 were swamp*
- 1 was stunted oaks
- 1 was mixed forest of cedar, tamarack, poplar, and balsam

1866 description; of 27 current bur oak savanna sites:
- 27 burned. Intensity varied.
- 15 had some windfall after burning
- 10 received light intensity burning
- 7 received intermediate intensity burning
- 7 received high intensity "clear burning"
- 3 are large areas where burn intensity varied.

*some of these originally may have been patches of hardwoods. See below and discussion.

(personal observation), and this was probably also true in 1865. Bur oak has long been known as a very fire-resistant tree (for example Fowells, 1965), so it is likely some bur oaks from hardwood stands survived the fire.

Of the 4 non-hardwood locations, three sites (numbers 4, 5, and 12) were listed as swamp, and today are only small patches of oak savanna. Two factors show these "swamp" sites could have been small patches of hardwood vegetation within the swamp, or at least something other than swamp. First, McPhillips's (1864) cover letter to his superior mentions "hardwood and swamp in such small patches that I could not mark them on the plan." Second, these three sites today are small islands of bur oak vegetation in (or at the edge of) large, open pastures, indicating small patches of different conditions exist within the area. Only site 6 lacks a reasonable explanation for its savanna, but it is possible that hardwoods may have occurred in the interior of the site where there is little survey information.

There are many places in the township where hardwood stands burned that do not currently support savanna vegetation. There could be numerous reasons for this, but so far these sites have not been studied. In addition, many of the best working farms in the area occupy some of these locations, so in some cases it is impossible to know whether savanna vegetation occurred there at one time.

It is obvious that burning occurred prior to the major fire of 1865. McPhillips discussed soils in his cover letter, and remarked "Being so often run over by the fire the good soil is burnt off." As well, he describes several locations, including some where savanna occurs today such as site 15, as burnt (Figure 4). Thus there is at least an indication that fire has occurred more than once in some places, maintaining savannas at those locations.

There is some correlation with clear burning in the three larger sites in the southern part of the township. In general, most clear burnt areas were windfall prior to the fire of 1865 (compare Figures 4 and 6), and again, it is possible that some of these large windfalls had been hardwood forests prior to some earlier fire. In the fire of 1865 hardwoods rarely clear burned; most became areas of

FIGURE 6. Location of clear burning superimposed on 1863–64 hardwood distribution and current bur oak savanna study sites. Note that most clear burnt lots were windfall in 1863–64 (see Figure 2).

windfall (compare the northern part of the study area in Figures 4 and 5 for example). This gives some support to the likelihood that the windfalls and clear burns in the three large southern sites were probably hardwoods at one time. Regardless of what species they once were, the large windfalls present in 1863–4 probably were responsible for the particularly devastating and widespread nature of the fire in 1865.

It is possible more bur oak savannas existed, in either survey, than just the few well-described sites which are clearly this type of vegetation. Either surveyor might have encountered bur oak vegetation (especially bur oak woodland) and simply labeled it "hardwood." Fortunately, the few well-described sites give at least a positive indication that savannas existed, even if it is uncertain how many there were. Yet, most of the places labeled hardwood were probably not bur oak dominated because oak is never used as a bearing tree for those lots. Furthermore, the description of hardwoods is sometimes qualified as "good hardwood land," which probably would not have described a bur oak savanna. Good land to a homesteader either meant rich soil (savanna soil is generally shallow and rocky) or supporting useable or marketable timber (the savannas have small, almost stunted trees even now after 130 years of growth). Therefore, it is assumed that most of the current bur oak savannas did not exist in 1863–4 and were created in the single event of the 1865 fire.

None of the bur oak savannas in Sheguiandah Township have burned since the fire of 1865, and nearly all areas are currently used as livestock pasture and have been grazed more or less continuously since settlement times, according to local oral history. It is probable that grazing keeps these bur oak savannas in an open state, since adjacent bur oak areas outside livestock fences have grown into a closed woodland, dominated by bur oak but with a ground flora and composition more like a hardwood forest (Jones, 1996; Jones, unpublished data). Grazing also prevents fire by keeping fuel build-up low. Two lightning strikes observed in bur oak savannas resulted in burns of only a few meters, and the fire was not carried across the grassland (personal observation).

It appears that many of these savannas were created from a single fire, and that (in the absence of fire or grazing) these bur oak savannas can grow into woodland in roughly 130 years. Substrate, growing conditions, and seed stocks suitable for creating oak savannas exist on Manitoulin Island, but their origins appear to be left to the randomness of fire. If fire occurs (at least once in approximately 130 years), existing savannas may be maintained. If fire does not occur, the savannas may grow into hardwood forests only to be re-created again some day in another major fire. Therefore, it is suggested that burning be tested as a management tool for the maintenance of this rare and interesting vegetation type.

ACKNOWLEDGEMENTS

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CONTENTS

On the cover: *Fire-charred remnant in a bur oak savanna, Sheguiandah Township, Manitoulin Island, Ontario. Photograph by Judith Jones, R.R. #3, Sheguiandah, Ontario*

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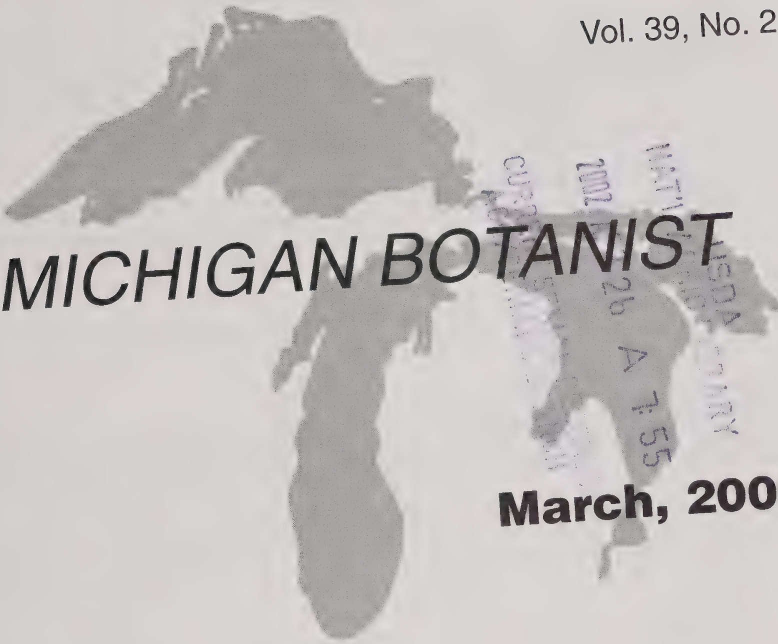

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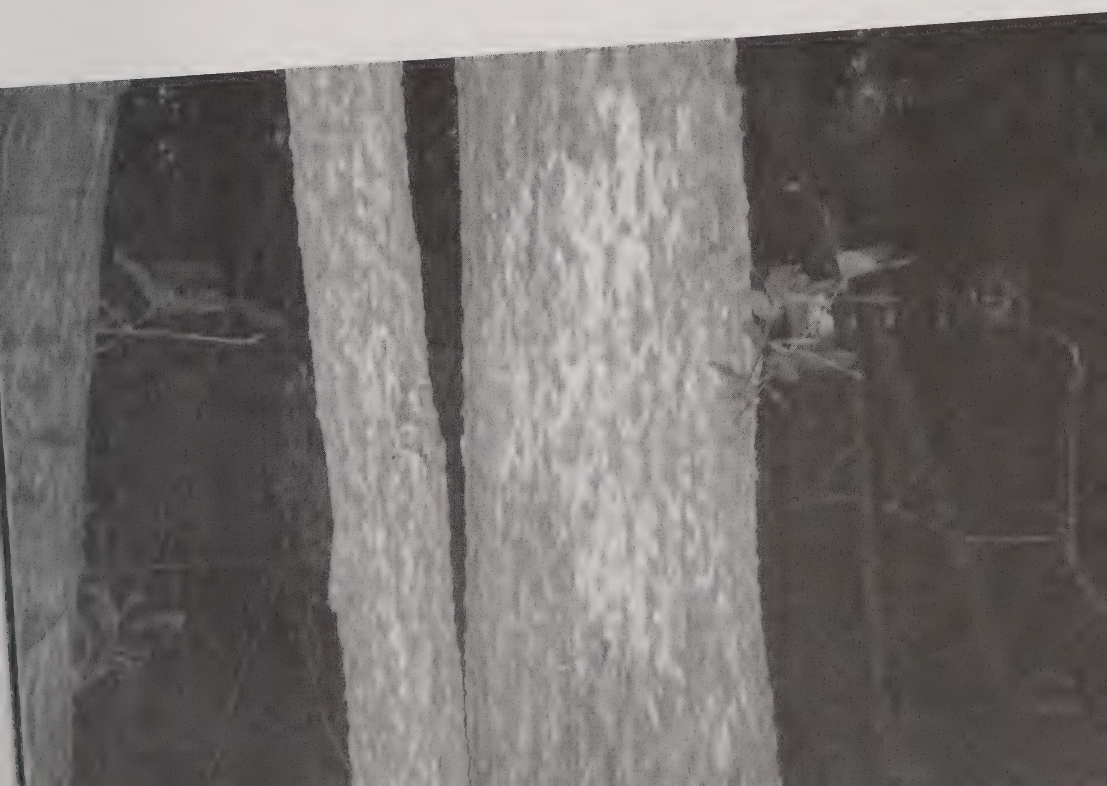

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TAXONOMY, ECOLOGY, AND BIOGEOGRAPHY OF *CAREX* SECTION *OVALES* IN INDIANA

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ABSTRACT

The most recent treatment of *Carex* section *Ovales* for Indiana dates to Deam's 1940 "Flora of Indiana." This updated treatment, based upon a thorough review of herbarium material and recent field studies, increases the number of taxa in the state from 17 to 20. Additions include *C. missouriensis* P. Rothr. & Reznicek, *C. projecta* Mackenzie, and *C. tenera* Dewey var. *echinodes* (Fernald) Wiegand. Nineteen species occur in northern-most Indiana. Southern Indiana is characterized by fewer and widespread species from *Carex* section *Ovales*; only *C. albolutescens* Schweinitz has a predominately southern distribution in the state. Salient taxonomic and ecological notes are provided for each species as well as a key to 27 taxa occurring in Indiana and nearby Illinois, Michigan, and Ohio.

Key words: *Carex*, section *Ovales*, biogeography, distribution, Indiana flora, Midwest flora

INTRODUCTION

Charles C. Deam served as a pioneer in the development of modern state floras. His "Flora of Indiana" (Deam 1940) set a standard for thoroughness and the breadth and depth of collections used as a floristic database. In the decades since the publication of the "Flora," there has been further progress in our understanding of Indiana's flora. These efforts have included floras of significant natural features such as Yellow Birch Ravine Nature Preserve (Yatskievych & Yatskievych 1987) and Mounds State Park (Rothrock *et al.* 1993). There also has been the publication of numerous county records for rare and unusual plants, the product of a vigorous Natural Heritage program within the Indiana Department of Natural Resources. And, of course, the "Flora of the Chicago Region," which includes northwest Indiana, has gone through 4 editions (Swink & Wilhelm 1994).

In spite of these important floristic activities in the state, there has been a lack of a sustained, coordinated effort to maintain and update a statewide flora (Crovello & Keller 1981). In fact, several important herbarium collections in Indiana have suffered due to lack of active use. Recently, efforts of the Indiana Academy of Science's Biological Survey and Natural Areas Committee (Jacquart 1999) have begun to reinvigorate the study of Indiana's biota. The Indiana Biological Survey (www.indianabiologicalsurvey.org), as an initial step, has initiated development of a unified database of collections across the state. As envisioned, this searchable database would result in the creation of a virtual museum collection

and an ability simultaneously to query multiple herbaria that house Indiana material. In light of these developments, it is timely to review some of the taxonomically complex plant groups in Indiana.

Carex L., with approximately 100 species in Indiana (Deam 1940), is the largest genus in the state's flora. *Carex* section *Ovales*, with at least 17 species, is the largest and most complex section within the genus. Although the treatment in the "Flora" was very ably done by Frederick Hermann, then at the University of Michigan, section *Ovales* has become both better understood (e.g., Rothrock 1991, Rothrock *et al.* 1997, Rothrock & Reznicek 2001) and better collected in the intervening years. We undertook a critical review of *Carex* section *Ovales* with two purposes: (1) to provide a dataset for testing and implementing the database model of the Indiana Biological Survey and (2) to furnish an updated treatment, in traditional format, of the taxonomy, biogeography, and ecological characteristics of those species occurring in Indiana.

MATERIALS AND METHODS

Collections of *Carex* section *Ovales* from Indiana were verified and entered into a relational database from the following herbaria: BUT, IND, MICH, MOR, ND, and PUL. MOR contains recent collections by G. Wilhelm, F. Swink, and co-workers; MICH as well as BUT contain personal collections by A.A. Reznicek and P.E. Rothrock. These significantly enhance and up-date the records for members of this section in Indiana.

In order to explore the biogeography of section *Ovales*, the counties of Indiana were grouped into seven bioregions (Fig. 1) based upon Homoya (1985). Due to its very small size, Homoya's Black Swamp Natural Region had to be merged with the Central Till Plain Natural Region for the purposes of this analysis. Similarly, the small Southern Bottomlands Region had to be combined with the Southwestern Lowlands Natural Region and Shawnee Hills with Highland Rim. The maps of species distribution resolve only to the county level. As a result, counties that straddle 2 regions were assigned to a single region based upon which natural region occupied the greatest portion of the county. In this analysis, the smallest natural region, the Northwestern Morainal region, included 3 counties. The largest region, the Central Till Plain, consisted of 34 counties.

RESULTS AND DISCUSSION

Overall Biogeographical Observations

Hermann's treatment (in Deam 1940) of the genus *Carex* for Indiana reported 17 species in section *Ovales*. Three additional taxa are included in our treatment: *C. missouriensis* P. Rothr. & Reznicek, *C. projecta* Mackenzie, and *C. tenera* Dewey var. *echinodes* (Fernald) Wiegand. Of these 20 taxa, two have only single reports for Indiana—*Carex cumulata* (L.H. Bailey) Mackenzie and *C. missouriensis* (Fig. 2; Table 2). As detailed below, an extant population of *C. cumulata* was documented. However, it is very likely that *C. missouriensis* has been extirpated from the state. Six species of *Carex* section *Ovales* are very widespread (Table 2), having at least one record in each Natural Region of Indiana (Fig. 1). Seven additional species—*C. argyrantha*, *C. crawfordii* Fernald, *C. merritt-fernaldii* Mackenzie, *C. opaca* (Hermann) P. Rothr. & Reznicek, *C. praticola* Rydberg (an adventive), *C. reniformis*, and *C. tincta*—are not known

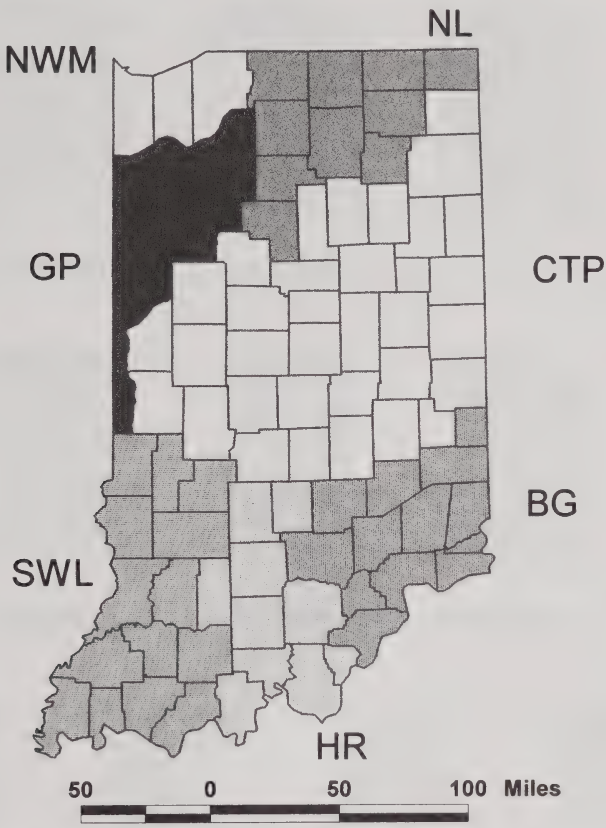

FIGURE 1. The natural regions in Indiana simplified from Homoya (1985) to county-level resolution. BG = Blue Grass; CTP = Central Till Plain; GP = Grand Prairie; HR = Highland Rim; NL = Northern Lakes; NWM = Northwestern Morainal; SWL = Southwestern Lowlands.

for Indiana but have been reported within a 4 county distance in Illinois, Michigan, and Ohio.

The distribution maps (Fig. 2; Table 1) indicate that species diversity in section *Ovales* is biased toward northern and especially northwestern Indiana. The largest number of species (18 out of 20) occurs in the Northwest Morainal (NWM) Natural Region (Table 1). The Northern Lakes (NL) and Grand Prairie (GP) also have high diversity (15 and 14 respectively). Four taxa are fully limited to these northern Natural Regions, while another 6 exhibit a predominately northern distribution in Indiana (Table 2). In contrast, only one species, *C. albolutescens*, has a predominately southern distribution in the state (Fig. 2; Table 2).

We primarily explain this biogeographical pattern on the basis of the diversity of soils and community types in the recently deglaciated areas of northern Indiana. Here one finds a broad range of substrates including coarse grained to peaty, acidic soils as well as fine grained, mineral-rich soils (Ulrich 1966). As a result,

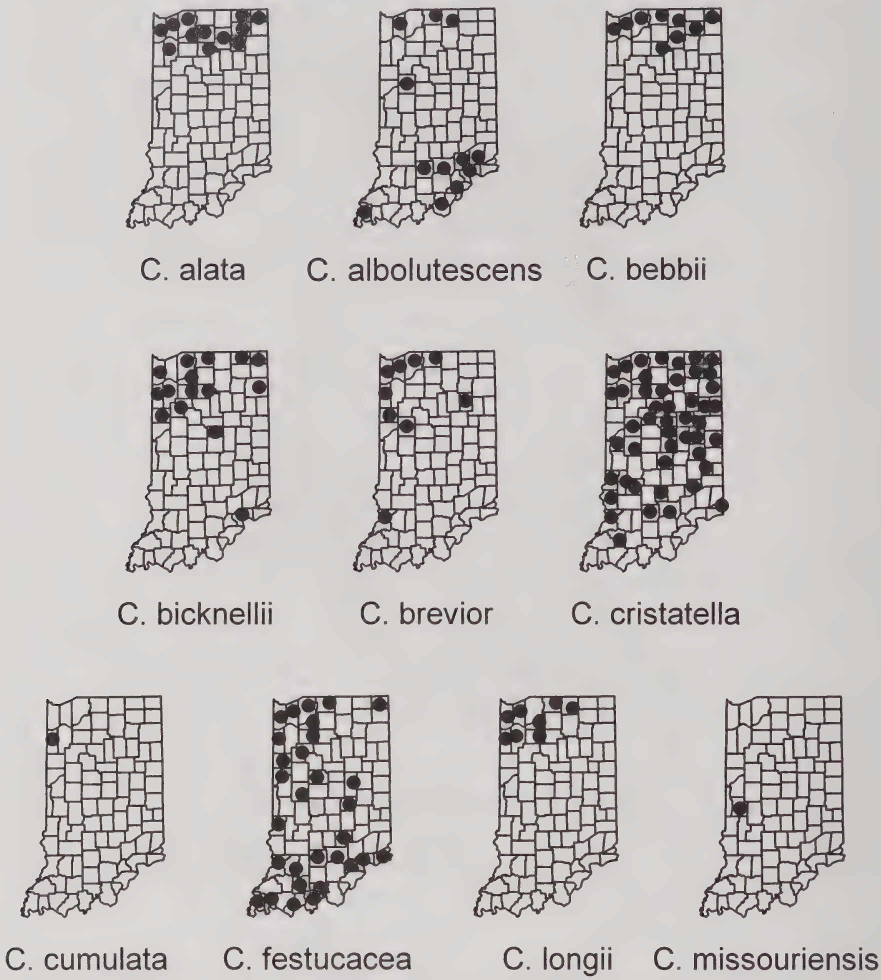

FIGURE 2. Atlas depicting distribution of members of *Carex* section *Ovales* in Indiana.

the northern Natural Regions support both the widespread species (largely those adapted to heavy, mineral-rich soils) as well as a suite of species that favors more acidic soils. Secondarily, the high diversity of *Ovales* species in northern Indiana is a result of broadly distributed species that reach a southern range limit in the Great Lakes region. These include the transcontinental species *C. bebbii* and *C. tenera* var. *tenera* as well as the northern hardwoods species *C. projecta*.

The Central Till Plain (CTP) Natural Region supports 14 taxa (Table 1). This

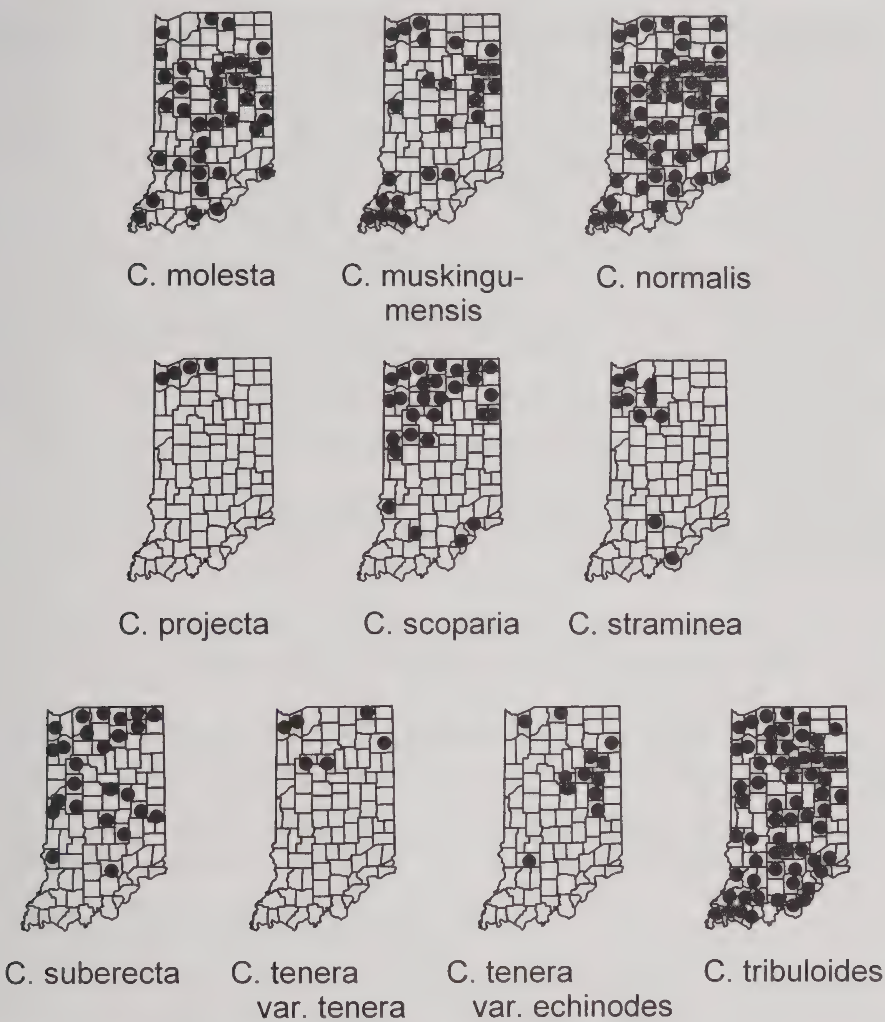

FIGURE 2. Continued

diversity reflects both the large geographical area encompassed by the CTP and the infrequent presence of some northern elements such as *C. scoparia.* In addition, the CTP supports the preponderance of sites for one taxon, *C. tenera* var. *echinodes.*

The Highland Rim (HR) Natural Region has the lowest diversity for section *Ovales* (Table 1). This portion of Indiana is characterized by rugged, well-drained terrain and a scarcity of natural bodies of water and wetlands.

TABLE 1. Number of taxa of *Carex* section *Ovales* by biogeographical region.

Bioregion	Number of Taxa
Northwest Morainal (NWM)	18
Northern Lakes (NL)	15
Grand Prairie (GP)	14
Central Till Plain (CTP)	14
Southwestern Lowland (SWL)	11
Blue Grass (BG)	10
Highland Rim (HR)	9

TABLE 2. Distributional Patterns of *Carex* section *Ovales* in Indiana

Widespread: *Carex cristatella*, *C. festucacea*, *C. molesta*, *C. muskingumensis*, *C. normalis*, *C. tribuloides*

Limited to northernmost bioregions—NWM, NL, and GP: *Carex alata*, *C. bebbii*, *C. longii*, *C. projecta*

Predominately northern in distribution in Indiana: *Carex bicknellii*, *C. brevior*, *C. scoparia*, *C. straminea*, *C. suberecta*, *C. tenera* var. *tenera*

Predominately southern in distribution in Indiana: *Carex albolutescens*

Predominately found in the Central Till Plain: *Carex tenera* var. *echinodes*

Rare: *Carex cumulata*, *C. missouriensis*

KEY TO SPECIES OF *CAREX* SECTION *OVALES* FROM INDIANA AND ADJACENT REGIONS.

(The key includes seven species, identified with an *, that have not been found in Indiana but occur within a four county distance in Illinois, Michigan, or Ohio).

1. Pistillate scales about as long as or longer than mature perigynia, usually concealing the beaks (though not necessarily the bodies), obtuse to acuminate, but not awned
    2. Perigynium beaks flat, winged, and ciliate-serrulate to apex; perigynia finely granular-papillose, 3–4.5 mm long .... **C. argyrantha*
    2. Perigynium beaks cylindric, unwinged, and more or less entire for 0.4 mm or more from apex; perigynia smooth, usually 4.5–6.5 mm long .... **C. praticola*
1. Pistillate scales (awns, if any, excluded) shorter than the perigynia at least in the middle portions of the spikes, the apical portion narrower than the beaks and not completely covering them, awned in some species
    3. Pistillate scales in the middle or lower portions of the spikes acuminate with a subulate tip or awned.
        4. Perigynia 2.6–4 times as long as wide; the bodies lance-ovate to lanceolate, 0.9–2 mm wide .... to couplet 15
        4. Perigynia less than 2.5 times longer than wide; the bodies narrowly ovate, ovate, broadly elliptic, circular, or obovate, 1.8–3.9 mm wide.
            5. Larger perigynia (5.8–) 6–7.1 mm long, with beaks 2–2.8 mm long; pistillate scales with the acuminate-awned apex white-hya-

line, fragile and often curled, the midrib not extending into the very tip. . . . . *C. missouriensis*

5. Larger perigynia (2.3–) 2.5–5.5 mm long, with beaks 0.85–2.3 mm long; pistillate scales with the apex firm, greenish to reddish-brown, straight, the midrib extending to the very tip.
   6. Perigynium bodies clearly obovate, often with conspicuous “shoulders,” abruptly contracted into the beak; broadest leaves 2.5–6 mm wide . . . . *C. alata*
   6. Perigynium bodies elliptical, circular, or weakly obovate, gradually tapered to gently contracted into the beak; broadest leaves 1.5–3 (–3.7) mm wide.
      7. Perigynium bodies cuneately tapering to the base, the base therefore subacute and the body ± diamond shaped; inflorescences ± compact, stiffly erect, with 3–5 spikes . . . . *C. suberecta*
      7. Perigynium bodies convexly tapered to the base, the base therefore rounded and the body elliptical, circular or weakly obovate; inflorescences ± compact to elongate and nodding, with 3–9 spikes.
         9. Pistillate and staminate scales with white-hyaline to pale yellowish margins; perigynia greenish to straw colored or pale brown, (2.3–) 2.5–4 (–4.2) mm long, with 0–4 often indistinct nerves on the inner face . . . . *C. festucacea*
         9. Pistillate and staminate scales with reddish-brown margins; perigynia reddish-brown, (3.8–) 4–5.5 mm long, usually with 5 or more conspicuous nerves on the inner face . . . . *C. straminea*

3. Pistillate scales obtuse or merely acute
   10. Perigynia 2 mm wide or less
      11. Leaf sheaths loose and expanded near the summit, uniformly pale or greenish, sharp-edged or bearing narrow wings continuous with the midrib and/or edges of the leaf blade; widest blades 3–7 mm wide; perigynia often thin and scale-like, the wings often conspicuously narrowed (even indented) near the middle of the body to form a cuneate base; vegetative shoots with leaves spreading and spaced along distal 1/2 of the shoot
         12. Perigynia stiffly spreading or recurved, the spikes more or less globose; pistillate scales 1.6–2.3 mm long, usually hidden between perigynia; summit of leaf sheaths and/or ligules often rust-tinged. . . . . *C. cristatella*
         12. Perigynia loosely spreading, ascending, or appressed, the spikes subglobose to ovoid-oblong; pistillate scales 2–3 mm long, evident in the spikes; summit of leaf sheaths and ligules not colored

13. Inflorescences stiffly erect, oblong, spikes overlapping; perigynia usually more than 40, beaks appressed-ascending; lower leaf sheaths firm at summit . . . *C. tribuloides*
13. Inflorescences arching or nodding, the lower spikes usually separated; perigynia 15–40, loosely spreading or ascending; lower leaf sheaths friable at summit . . . . *C. projecta*

11. Leaf sheaths usually tight, the edges ± rounded, unwinged; widest blades 1–4 (–4.2) mm wide (or blades wider in *C. normalis* in which the sheaths generally have green veins contrasting with white intervenal areas); perigynia usually plumply planoconvex, the wings typically tapered evenly to the round or sometimes cuneate base; vegetative shoots with leaves ascending and clustered at apex
    14. Perigynia 2.5–4 times as long as wide, the bodies lanceolate-ovate to lanceolate, the distance from beak tip to top of achene mostly 2.2–5 mm (about 3/5 the length of the perigynia)
        15. Perigynia 0.9–1.3 mm wide; achenes 0.6–0.8 mm wide; inflorescences dense, the lowest internodes 2–3(–5) mm long. . . . . *C. crawfordii
        15. Perigynia 1.2–2 mm wide; achenes 0.7–1.1 mm wide; inflorescences dense to open or arched, the lowest internodes 2–17 mm long
            16. Inflorescences erect to arching, dense or open but the spikes usually approximate; pistillate scales acuminate; perigynia usually ascending. . . . . . . *C. scoparia*
            16. Inflorescences arching or nodding, spikes well separated; pistillate scales obtuse or acute; perigynia spreading. . . . . *C. tenera* var. *echinodes*
    14. Perigynia less than 2.5 times as long as wide, the bodies obovate, circular, ovate, or narrowly ovate, the distance from beak tip to top of achene 0.8–2.2 mm (about 1/2 or less the length of the perigynia)
        17. Perigynium bodies obovate (widest above the middle of the body)
            18. Beaks appressed-ascending, triangular and gradually tapered from the body; pistillate scales obtuse; styles straight . . . . *C. longii*
            18. Beaks spreading, slender and abruptly contacted from the body; pistillate scales acute; styles with a strong S-loop at the base . . . . *C. albolutescens*
        17. Perigynium bodies narrowly ovate to circular (widest at or below the middle of the body)
            19. Inflorescences dense, more or less head-like, lowest internodes less than 6 mm long
                20. Sheaths strongly papillose (visible at 30×); pistillate scales dark rust or reddish-brown . . *C. tincta

20. Sheaths smooth; pistillate scales greenish to yellowish-brown
    21. Perigynia nerveless on adaxial face, 1.2–1.8 mm wide, rust-colored; achenes 0.6–0.9 mm wide . . . . *C. bebbii*
    21. Perigynia nerved on adaxial face or if nerveless then 1.8–3 mm wide, not rust colored; achenes 0.9–1.3 mm wide
        22. Leaf blades 2.5–6.5 mm wide, the mouth of sheaths prolonged up to 2 mm above base of leaf blades; perigynium bodies narrowly ovate (ca. 2–2.5 times as long as wide) and usually greenish or greenish-brown tinged . . . . *C. normalis*
        22. Leaf blades 1.5–4 mm wide, the mouth of sheaths concave or at most shortly prolonged above base of leaf blades; perigynium bodies broadly elliptic (mostly 1.5–2 times as long as wide), quickly turning pale- or yellowish-brown . . . . *C. molesta*

19. Inflorescences usually open at least proximally, lowest internodes greater than 6 mm long
    23. Perigynium bodies broadly elliptic to circular (0.9–1.3 times as long as wide), abruptly narrowed to beak; leaves 1–3.5 mm wide; lower pistillate scales (and adjacent staminate scales) acute . . . . *C. festucacea*
    23. Perigynium bodies ovate, lanceolate, or narrowly elliptic, gradually tapering to beak; leaves 1.3–6.5 mm wide; lower pistillate scales (and adjacent staminate scales) obtuse
        24. Sheaths at least sparsely papillose (visible at 30×) dorsally near the base of leaf blade, the lower sheaths not prominently whitish mottled nor cross-septate; perigynium beaks appressed or ascending, exceeding subtending scales by 0–0.8 mm, their shoulders straw-colored to reddish brown at maturity . . . . *C. tenera* var. *tenera*
        24. Sheaths totally smooth, the lower sheaths often whitish-mottled and cross-septate; perigynium beaks spreading, exceeding subtending scales by 0.7–1.6 mm, their shoulders greenish to greenish brown at maturity
            25. Widest leaves 2.5–6 mm wide; inflorescences erect to bent, the lowest intern-

odes mostly 6–10 (–11.5) mm long, the rachis stiff; plants forming small, ± erect clumps of less than 40 culms *C. normalis*

25. Widest leaves 1.5–3.5 mm wide; inflorescences arching or nodding, the lowest internodes (6–) 10–21 mm long, the rachis usually thin and wiry; plants often forming large, spreading clumps of many culms .... *C. tenera* var. *echinodes*

10. Perigynia greater than 2 mm wide
   26. Spikes 12–28 mm long with tapering bases and acute tips; perigynia lanceolate, 6–9 mm long; vegetative culms conspicuous at time of fruiting.......................... *C. muskingumensis*
   26. Spikes less than 12 mm long, or if longer, with rounded bases and/or tips; perigynia, if lanceolate, less than 6 mm long; vegetative culms absent or present at time of fruiting
      27. Perigynium bodies obovate (widest above the middle of the body); leaf sheaths green-nerved ventrally nearly to the summit; achenes 0.7–1.2 mm wide
         28. Beaks spreading, slender and abruptly contracted from the body; pistillate scales acute; styles with a strong S-loop at the base...................... *C. albolutescens*
         28. Beaks appressed-ascending, triangular and gradually tapered from the body; pistillate scales obtuse or acute; styles straight or occasionally bent
            29. Perigynia nerved on adaxial face; widest leaves 2–4 mm wide, their sheaths concave at summit *C. longii*
            29. Perigynia nerveless on adaxial face; widest leaves 3–6 mm wide, their sheaths truncate at summit or extending up to 3 mm above base of leaf blades .... *C. cumulata*
      27. Perigynium bodies lanceolate, ovate, elliptic, circular, or reniform (widest at or below the middle of the body); leaf sheaths various, some with a prominent hyaline band ventrally; achenes 0.9–1.9 mm wide
         30. Perigynia finely granular-papillose (visible at 30×), the body reniform, 0.6–0.9 times as long as wide (3.2–4.9 mm wide); lower pistillate scales obtuse-rounded .... **C. reniformis*
         30. Perigynia smooth, the body narrowly ovate, elliptic, or more or less circular, (0.7–) 0.9–2.5 times as long as wide (1.5–4.6 (–4.8) mm wide); lower pistillate scales obtuse to acuminate
            31. Larger perigynia 5–7.1 mm long, perigynia thin, biconvex (the bulge formed by the achene usually equally prominent on both perigynium faces)

32. Leaf sheaths finely papillose (visible at 30×); perigynia thin, translucent, usually with coppery-tinged wings, strongly and evenly 4–8-nerved over achene; pistillate scales usually reddish-brown; anthers (2.4–) 2.8–4.2 mm long; plants in small clumps in usually dry to mesic habitats . . . . *C. bicknellii*
32. Leaf sheaths smooth; perigynia ± thickened and opaque, with greenish or pale brown wings, finely and irregularly (0–) 1–7- nerved over achene; pistillate scales pale yellowish-brown; anthers 2.2–3.4 mm long; plants in dense, large clumps (up to 200 culms) in wet habitats . . . . **C. opaca*

31. Larger perigynia less than 5 mm long, perigynia usually plumply planoconvex at maturity
 33. Leaf sheaths green-ribbed ventrally nearly to sheath summit; spike tips acute; perigynia rust-colored at maturity, cuneately tapered to the base; beaks appressed, gradually tapered . . . . *Carex suberecta*
 33. Leaf sheaths with a white-hyaline area ventrally near the summit; spike tips obtuse or rounded; perigynia straw-colored, greenish, or sometimes brown at maturity, rounded to the base; beaks ascending to spreading, abruptly contracted (or gradually tapered in *C. normalis*)
  34. Perigynium bodies narrowly ovate to ovate (ca. 2–2.5 times as long as wide), greenish, the beaks gradually tapered; leaves 2.5–6.5 mm wide; proximal sheaths loose, intervenal areas often pale or whitish, the mouth of sheaths prolonged up to 2 mm above base of leaf blades . . . . *C. normalis*
  34. Perigynium bodies broadly ovate to circular (ca.1–2 times as long as wide), quickly turning pale- or yellow-brown or rust colored, the beaks often abruptly contracted from body; leaves 1–3.5 mm wide; proximal sheaths evenly colored and tight, the mouth of sheaths concave or at most shortly prolonged above base of leaf blades
   35. Leaf sheaths finely papillose (visible at 30×), especially near the base of the leaf blade
    36. Pistillate scales dark rust or reddish-brown; leaves of fertile shoots 2–4,

the leaf sheaths with ventral hyaline area sometimes puckered or cross-corrugated . . . . *C. tincta*

36. Pistillate scales greenish to yellowish; leaves of fertile shoots 3–6, the leaf sheaths not puckered
    37. Perigynia 2–2.4 (–2.6) mm wide; distance from summit of achene to tip of beak 0.8–1.5 mm; larger achenes 1–1.35 mm wide . . . . *C. festucacea*
    37. Perigynia 2.5–3.4 mm wide; distance from summit of achene to tip of beak 1.8–3.1 mm; larger achenes 1.3–1.5 mm wide . . . . *C. merritt–fernaldii*

35. Leaf sheaths smooth
    38. Spikes on larger inflorescences 2–4 (rarely more), rounded at the base, the terminal one lacking a conspicuous staminate base; inflorescences mostly 1.3–3 cm long (the lowest internodes generally 1.5–6 mm long); perigynium bodies elliptic to ovate (rarely circular), 1–1.6 times as long as wide. . . . . *C. molesta*
    38. Spikes on larger inflorescences (4–) 5–7 or more, tapered at the base, the terminal one with a conspicuous staminate base; inflorescences typically 2.5–4.5 (–6) cm long (the lowest internodes generally 5–13 mm long); perigynium bodies broadly ovate to circular, (0.7–) 0.9–1.2 times as long as wide
        39. Larger perigynia 3.2–4.7 (–5) mm long, 2.5–3.3 (–3.5) mm wide, the adaxial face usually nerveless; larger achenes 1.4–1.8 mm wide. . . . . *C. brevior*
        39. Larger perigynia 2.5–4 (–4.2) mm long, 1.5–2.4 (–2.6) mm wide, the adaxial face mostly 2–4-nerved; larger achenes 0.9–1.3 mm wide . . . . *C. festucacea*

NOTES ON INDIVIDUAL SPECIES

1. *Carex alata* Torrey. *Carex alata* is primarily distributed along the Atlantic coastal region from central Florida to southeastern New Hampshire (Rothrock *et al.* 1997). Inland it has several secondary centers of distribution: central New York, northwest Pennsylvania westward to Indiana, and southeastern Missouri to central Tennessee. In Indiana it is limited to northern counties were it thrives in mostly organic soils associated with fens, lake margins, wet prairies, red maple (*Acer rubrum*) or swamp white oak (*Quercus bicolor*) woods, tamarack (*Larix laricina*) swamps, and even *Sphagnum* bogs. Putative hybrids between *C. alata* and *C. scoparia* (Rothrock *et al.* 1997) and between *C. alata* and *C. tribuloides* (Mohlenbrock 1999) have been reported from Ohio and Illinois respectively.

2. *Carex albolutescens* Schweinitz. In some floras of the southeastern United States, this species has been confused with *C. festucacea*. Unlike *C. festucacea*, *Carex albolutescens* has clearly obovate perigynia with sharper adaxial nervation, narrower achenes, and a strong lateral sinuosity at the base of the style (Rothrock 1991).

In Indiana, *C. albolutescens* occurs primarily in the Ohio River Valley. It grows in mucky or sandy, acidic soils of swampy woods with pin oak (*Quercus palustris*), red maple, or sweet gum (*Liquidambar styraciflua*) or sometimes in wet sandy meadows.

3. *Carex bebbii* (L.H. Bailey) Fernald. In the field *C. bebbii* resembles a diminutive *C. cristatella* in that both have somewhat spherical spikes with numerous, small perigynia. Besides characters in the key to species, *C. bebbii* can be distinguished from *C. cristatella* by its narrower leaves (only reaching 4.2 mm compared to 7.5 mm in *C. cristatella*) that, on vegetative shoots, are clustered near the apex.

Carex bebbii is very broadly distributed across northern North America (Mastrogiuseppe *et al.*, in rev.). In Indiana, this species is limited to the northern counties where it grows in wet, usually calcareous soils of lake shores and wet prairies and occasionally in wet sandy soils.

4. *Carex bicknellii* Britton. *Carex bicknellii* has a center of distribution in the dry prairies of the upper Midwest, including Missouri, Iowa, Illinois, eastern Kansas, and southeastern Nebraska (Rothrock & Reznicek 2001). A secondary center of distribution extends from southeastern Pennsylvania to Massachusetts where *C. bicknellii* occupies barrens and other habitats with dry, sandy soils. *Carex bicknellii* is found in open habitats with sandy soils such as railroad right-of-ways, remnant prairies, old cemeteries, stabilized dunes, and open black oak (*Quercus velutina*) woods. These habitats are most often associated with the Northwestern Morainal and Grand Prairie Natural Regions of northwestern Indiana. The single Jefferson County collection (19 June 1935, *C.C. Deam 56228A*, IND) comes from a flat woods "on the Schuman farm, about 2 mi. NE of Hanover."

5. *Carex brevior* (Dewey) Lunell. A review of herbarium materials indicated that Deam's (1940) "Flora" did not clearly differentiate this species from *C. molesta*. As described in the key to species, spike number and shape and perigynium shape separate these two taxa. In addition, the achenes of *C. brevior* are much wider than those of *C. molesta* (larger achenes 1.4–1.8 mm wide versus larger achenes 0.9–1.3 mm). *Carex brevior* is most common in portions of Indiana with prairie elements, particularly the northwestern counties. Here *C. brevior* occurs in sandy soils of fields, dunes, and open woods. The Huntington County collection is a waif of a road verge. *Carex brevior* occasionally may be found in the eastern and southeastern United States, outside its natural range, as a weed of road verges. More robust specimens of *C. brevior* sometimes resemble *C. merritt-fernaldii* and, in fact, the L.M. Umbach (*5289*, MICH) collection from Port Chester in Porter County was originally identified and annotated as *C. merritt-fernaldii*. The two species are most easily distinguished by their leaf sheaths. Those of *C. brevior* are always smooth, while those of *C. merritt-fernaldii* have fine papillae (visible at 30×).

6. *Carex cristatella* Britton. This species is common in unshaded marshes, edges of ponds and lakes, wet ditches, wet woods, river banks, and swampy floodplains throughout most of Indiana. In southernmost Indiana this species is infrequent and near a southern limit of its range.

Sometimes *C. cristatella* is confused with *C. tribuloides*. However, normal vigorous specimens are easily distinguished from *C. tribuloides* by the globose shape of the spikes. Of the 2 species, *C. cristatella* is much less tolerant of shaded conditions. Also, unlike *C. tribuloides*, decumbent culms of *C. cristatella* do not seem to root at their nodes. Both species have relatively late flowering and fruit maturation periods for members of section *Ovales*. Mature achenes develop in early July and can be retained on the inflorescence until mid-August. The majority of *Ovales* species shed mature fruit by the third or fourth week of June.

7. *Carex cumulata* (L.H. Bailey) Mackenzie. Morphologically *C. cumulata* is most similar to *C. longii* but has more conic spikes and strongly concave perigynia without adaxial nervation. In spite of searching for this species in other likely sites in Indiana (such as Jasper-Pulaski Fish and Wildlife Area), we found *C. cumulata* to be limited to Willow Slough Game Preserve in Newton County. It also occurs in Illinois in adjacent Kankakee (Swink & Wilhelm 1994) and Iroquois (*Reznicek 10836*; ILLS, MICH) Counties. At Willow Slough, this species grows in sandy, acidic soils of pin oak savannas, especially along fire-breaks where there is periodic disturbance. It declines as the *Polytrichium* moss stage of succession is reached. As a further ecological note, the achenes of *C. cumulata* ripen in mid-August, late for a member of section *Ovales* and, unlike other species in the section, do not readily germinate without a pre-treatment of moist stratification (Rothrock, unpublished data).

8. *Carex festucacea* Willdenow. In the field, *C. festucacea* looks like *C. brevior* with small perigynia and has occasionally been confused with it in herbaria. In

Indiana, *Carex festucacea* has a wider distribution than *C. brevior*, occupying a range of wet or seasonally wet habitats such as low flatwoods (especially with pin oak), wooded ravines, wet fields and prairie, and low roadsides and ditches. Less often, this species may be found in drier habitats such as wooded slopes.

9. *Carex longii* Mackenzie. *Carex longii* is common along the Atlantic and Gulf of Mexico coastal plain. In fact, it has an almost weedy quality in the southern United States where it enters early successional habitat with sandy soils, reaches reproductive maturity quickly, and can spread to some degree through the rooting of decumbent culms. Disjunct populations occur to the west of Lake Erie and east and south of Lake Michigan. In Indiana, *C. longii* is limited to the northwestern counties (especially the Northwestern Morainal and Grand Prairie Natural Regions). Here it inhabits wet or seasonally wet, acidic, sandy soils of open woods dominated by pin oak or red maple, marshes, fields, and prairies. Less often, *C. longii* is found in drier habitats or *Sphagnum* bogs. Some manuals (e.g. Gleason 1952; Radford *et al.* 1964) have reduced *C. longii* to synonymy with *C. albolutescens*. Rothrock (1991) demonstrated that the two are clearly distinctive species. Mature fruits are produced in early July.

10. *Carex missouriensis* P. Rothrock & Reznicek. This recently described species superficially resembles *C. bicknellii*. *Carex missouriensis* favors wet habitat, typically prairie swales, compared to the more mesic to dry habitats of *C. bicknellii*. The single 1944 record for *C. missouriensis* in Indiana is from a "wooded ravine 5 mi NE of Clinton" (*R.M. Kriebel 10198,* PUL). Efforts to relocate the population were unsuccessful, although an area along US 41, now occupied by a dwelling and a stream swale invaded by *Phalaris arundinacea*, appears to be the most likely site.

11. *Carex molesta* Bright. Although described in Deam (1940) as infrequent to rare, *Carex molesta* is actually widespread in Indiana. It seems to be particularly frequent in the heavy, calcareous soils of the Central Till Plain region of east central Indiana. *Carex molesta* thrives in early to mid-successional habitats including mesic to wet roadside banks and ditches, low edges of fields as well as edges of marshes, and wooded openings.

12. *Carex muskingumensis* Schweinitz. This is the most distinctive member of *Carex* section *Ovales* with lanceolate perigynia reaching 7–10 mm in length. Deam (1940) indicates that this species can form extensive and pure stands in wet woods. *Carex muskingumensis* is particularly abundant in the lower Wabash basin of southwestern Indiana. It also occurs frequently in depressional woods with pin oak, swamp white oak, and silver maple (*Acer saccharinum*) in the Central Till Plain Region and in depressional and floodplain woods in the Northwestern Morainal Natural Region. Swink & Wilhelm (1994) noted that this species prefers soils of high organic leaf and root litter content positioned over mud. Although often growing near *C. tribuloides*, only a single hybrid specimen (with sterile achenes) has been found between these two species (Posey Co., *Reznicek et al. 10852,* BUT, MICH, WIS).

13. *Carex normalis* Mackenzie. *Carex normalis* has broad ecological amplitude; it is frequent in mesic to moist or dry open woods and thickets throughout Indiana. Herbarium labels include wooded slopes especially associated with rivers; flat beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*), or white oak (*Quercus alba*) woods; flat post oak (*Quercus stellata*) woods; wooded bluffs and ravines; woods of creek floodplains; and thickets near ponds, lakes, or ditches. The soils are mineral with low organic content.

14. *Carex projecta* Mackenzie. This species was not listed by Deam (1940) since most collections have been made since 1970. *Carex projecta* reaches a southern limit of its range in the extreme northwestern counties of Indiana. Swink & Wilhelm (1994) describe it as a species of morainic slopes and riparian terraces.

Many Indiana collections of *C. projecta* are difficult to separate from a related species, *C. tribuloides*, even though, in our experience, the two species are readily distinguished farther north. Further taxonomic study may be warranted. On the one hand, Mastrogiuseppe *et al.* (in rev.) suggest that *C. projecta* is in many respects intermediate between *C. cristatella* and *C. tribuloides*; and yet, available chromosome counts (Whitkus 1991) indicate that *C. projecta* (with $n = 32$ versus $n = 35$ for *C. tribuloides* and *C. cristatella*) is distinct from both these species. We attribute the problematic nature of Indiana collections of *C. projecta* to the fact that they come from small, physiologically stressed populations at the periphery of their geographic range.

15. *Carex scoparia* Willdenow. Although *C. scoparia* can be a very common species in the northeastern United States and adjacent Canada, it is more restricted in distribution in Indiana. This species can be frequent in the northern quarter of Indiana in unshaded borders of lakes, marshes, low fields, wet prairies, wet railroad right-of-ways, sedge meadows, interdunal flats, and open pin oak woods. The scattered occurrences of *C. scoparia* in southern Indiana include habitats such as low fields or old pastures, wet woods, and sedge-filled roadside depressions. The soils are frequently sandy and acidic. Because *C. scoparia* has much intraspecific variation, Fernald (1950) lists 6 forms and varieties. None of these are particularly useful in Indiana.

16. *Carex straminea* Willdenow. Known as *C. richii* in Deam (1940), *C. straminea* is most characteristic of open pin oak, river birch (*Betula nigra*) swamp woods as well as sedge meadows and lake margins in northwestern Indiana. It typically grows in acidic sandy or peaty soils. A very large population has been located at Willow Slough Game Preserve. Disjunct populations of this rare sedge occur in Harrison and Lawrence County. Putative sterile hybrids (Rothrock *et al.* 1997) have been reported between *C. straminea* and *C. scoparia* (White County) and with *C. longii* (Newton County).

17. *Carex suberecta* (Olney) Britton. This species inhabits calcareous soils of unshaded fens, lake margins and seepages, tamarack swamps, and prairie swales, especially in the northern half of Indiana. Putative sterile hybrids between this

species and *C. scoparia* have been reported (Rothrock *et al.* 1997) for Lake County.

18. *Carex tenera* Dewey var. *tenera*. The typical variety of *C. tenera* is rare in Indiana. Swink and Wilhelm (1994) describe it as a species of wet to mesic savannas and prairies. It also has been reported from wooded slopes and dry open woods.

19. *Carex tenera* Dewey var. *echinodes* (Fernald) Wiegand. Preliminary investigation indicates that this taxon should be recognized as a species distinct from typical *C. tenera* and may, in fact, be more closely related to *C. normalis*. In Indiana, *C. tenera* var. *echinodes* often occupies the margins of vernal pools in flat, swampy woods with pin oak, swamp white oak, and red maple. These habitats are frequent in the eastern Central Till Plain Natural Region; however, the populations observed have consistently been of small size, usually fewer than 5 clumps.

20. *Carex tribuloides* Wahlenberg. *Carex tribuloides* is one of the most common *Ovales* species in Indiana. It grows in swampy flat woods as well as banks of streams, seepages, marshes, and wet prairies. The soils range from peaty to rotting logs to mineral-rich. Decumbent culms of *C. tribuloides* can root at their nodes resulting in vegetative spread, a trait not observed for *C. cristatella* and infrequently for *C. projecta*.

Mackenzie (1931) recognizes variety *sangamonensis* Clokey. These plants have more slender leaves (seldom reaching 4.0 mm wide) and shorter perigynia (averaging ca. 3.2 mm). In its extreme, this variety is distinctive and is the common form of the species in the lower Mississippi valley. Some specimens from the southern half of Indiana (e.g. Clay, Fountain, Jennings, Knox, Pike, Rush, and Warrick Counties) can be assigned to variety *sangamonensis*. More work is needed to assess the distinctness and distribution of this entity.

ADDITIONAL SPECIES KNOWN FROM ADJACENT ILLINOIS, MICHIGAN, AND OHIO

1. *Carex merritt-fernaldii* was verified from Lucas County, Ohio (Rothrock & Reznicek 2001). *Carex merritt-fernaldii* is most frequent in parts of southern Ontario eastward into Maine, northern New England, and New Brunswick where soils are well-drained, leached, acid sands or gravels.

2. *Carex crawfordii* was collected from Lake County, Illinois in 1991 from a degraded marsh (Mohlenbrock 1999). This northern, transcontinental species is typically found in wet sandy shores, meadows, and ditches in acidic, sandy or organic soils.

3. *Carex opaca* has recently been reported from Saline, St. Clair, and Washington Counties, Illinois (Rothrock & Reznicek 2001). This species is fairly infre-

quent throughout its range but reaches its greatest abundance in areas surrounding the Ozark Mountain system where it inhabits unshaded, poorly drained habitats including highway right-of-ways and "rice prairies."

4. Swink & Wilhelm (1994) and Mohlenbrock (1999) note *Carex praticola* as an adventive to a cemetery in Cook County, Illinois.

5. *Carex reniformis* is known from Massac County, Illinois, as noted by Mohlenbrock (1999).

6. *Carex argyrantha* is known from two collections in Berrien County, Michigan, on wooded dunes near Lake Michigan (*Henderson 140,* MICH; *Reznicek 9522,* MICH). Efforts to find it in nearby areas of Indiana have so far been unsuccessful.

7. *Carex tincta* is rare in the western Great Lakes region. Our only nearby collection, dating from June 1923, comes from DuPage County, Illinois (*A. Butler s.n.,* F).

The distinctive *Carex sychnocephala*, with leafy-bracted heads, is known as close to Indiana as Hillsdale County, Michigan (Fritsch 1993). However, although placed in section *Ovales* in some works (e.g., Fernald 1950, Gleason 1952), it is here placed in section *Cyperoideae*.

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NOTEWORTHY COLLECTION

MICHIGAN

PINUS NIGRA Arnott (Pinaceae) Austrian or Black Pine

Previous knowledge. *Pinus nigra* is a native of Europe widely introduced as an ornamental tree. It was reported to "escape locally" in the northeastern United States and adjacent Canada (Gleason & Cronquist 1991), but was given only incidental mention in the Flora of North America (Kral 1993). *Pinus nigra* was reported as naturalized (successfully reproducing and surviving without human intervention) in Illinois (Pepoon 1927). It was not included in the Michigan Flora (Voss 1973), which included non-native species only if established or naturalized. More recently, *P. nigra* was reported to become naturalized in western Michigan, where originally planted to stabilize sand dunes (Leege & Murphy 2000). It was also reported as "spreading in the Pacific Northwest" (Petrides & Petrides 1998) without specifics.

Significance. This is the first report of naturalized *Pinus nigra* from a broad area (six adjacent counties) of Michigan. The actual frequency with which established populations are encountered along Michigan roadsides is believed to be much greater than indicated by the few specimens cited here. Originally planted along highways, individuals of the species have fully reached sexual maturity in the past 10–15 years. From those trees the species has been slowly becoming established in suitable, open habitat with a low density of grasses and other vegetation. At each site cited below, there were mature trees with many seedlings and saplings commonly ranging from 15 cm to more than 4 m tall. The high density of young trees can be used as an indicator that the seedlings were not planted.

Diagnostic characters. *Pinus nigra* is most likely to be confused with the native *P. resinosa*. The non-native species may be distinguished from the native by its fresh leaves, which bend rather than break when sharply folded; its seed-cone scales, which are cream to light brown or gray, not light red-brown, at the time of seed shed, and some of which bear a minute prickle (easily broken off) that is absent in *P. resinosa*; and its winter buds, which are pale silvery instead of reddish brown (Kral 1993), though that is a difficult distinction. Also, the bark, especially at a distance, appears dark gray instead of pinkish or reddish brown. Length of leaves on seedlings is shorter than that of adults.

MICHIGAN. GENESEE CO.: Near Fenton, northbound entrance ramp of US highway 23 at Owen Road, T5N R6E Sec. 34, west-facing slope, open prior to growth of pines, about 10 adults with 23 offspring 20–60 cm tall and 35 offspring 0.6–2 m tall, 7 March 1999, *B. D. Parfitt 6040 & C. A. Wade* (MICH, UMF); West of Grand Blanc, northbound exit ramp from US highway 23 onto Grand Blanc Road, T6N R6E Sec. 23 NE¼ NW¼, west-facing slope, dozens of offspring of all sizes in a thicket near adults, 7 March 1999, *B. D. Parfitt 6048 & C. A. Wade* (MICH, UMF); Between Davison and Goodrich along the west side of state highway 15 (M-15), T6N R8E Sec. 27 NW¼, open dry 20–30° east-facing slope, three mature trees with about 75 seedlings and saplings of all ages, 1 June 1998, *B. D. Parfitt 6020 & J.*

Parfitt (MICH, UMF); Southwest of Flint, south side of highway I-69 0.6 mile west of Bristol Road, T7N R6E Sec. 32 NE¼, open north-facing slope, numerous adults and dozens of offspring less than 1 m tall, 7 March 1999, *B. D. Parfitt 6047 & C. A. Wade* (MICH, UMF). INGHAM CO.: Southwest of Webberville, eastbound entrance ramp from state highway 52 onto highway I-96, T1N R2E Sec. 15 NW¼ NE¼, north-facing slope, 9 adults and 48 offspring 0.3–2 m tall, 7 March 1999, *B. D. Parfitt 6044 & C. A. Wade* (MICH, UMF). LIVINGSTON CO.: Between west side of US highway 23 (milepost 68) and access road (old US 23), 0.7 mile north of state highway 59 (M-59), T3N R6E Sec. 21 NW¼, east-facing slope, 10 adults and 35 offspring 0.2–1+ m tall, 7 March 1999, *B. D. Parfitt 6041 & C. A. Wade* (MICH, UMF). OAKLAND CO.: East of Holly, junction of Buckell Road and Dixie Highway, T5N R8E Sec. 33 NW¼, east edge of woods, 3 adults and 20–30 offspring 0.6–5 m tall, 7 March 1999, *B. D. Parfitt 6036 & C. A. Wade* (MICH, UMF); East of Holly, between southbound exit ramp of I-75 and southbound lanes at Grange Hall Road, T5N R7E Sec. 24 SE¼, open grassy area, about 8 adults and a dozen offspring 30–60 cm tall, 7 March 1999, *B. D. Parfitt 6038 & C. A. Wade* (MICH, UMF). SHIAWASEE CO.: North edge of Perry, north side of Lansing Road (old highway I-69), about 0.2 mile east of state highway 52 (M-52), T5N R2E Sec. 10 SW¼, roadside edge of old field, more than 6 adults with dozens of offspring 3–7 m tall and one 2 m tall, 7 March 1999, *B. D. Parfitt 6046 & C. A. Wade* (MICH, UMF). WASHTENAW CO.: Northeast side of Ann Arbor about 1 mile north of Plymouth Road, west side of US highway 23 at state highway 14 (M-14) east, T2S R6E Sec. 11 S½, open east- or northeast-facing slope, 3 adults and 25 offspring 0.6–3 m tall, 7 March 1999, *B. D. Parfitt 6042 & C. A. Wade* (MICH, UMF); Southbound exit ramp from US highway 23 to Plymouth Road, T2S R6E Sec. 14 SE¼, open east-facing slope, dozens of adults and dozens of offspring of all sizes, 7 March 1999, *B. D. Parfitt 6043 & C. A. Wade* (MICH, UMF)

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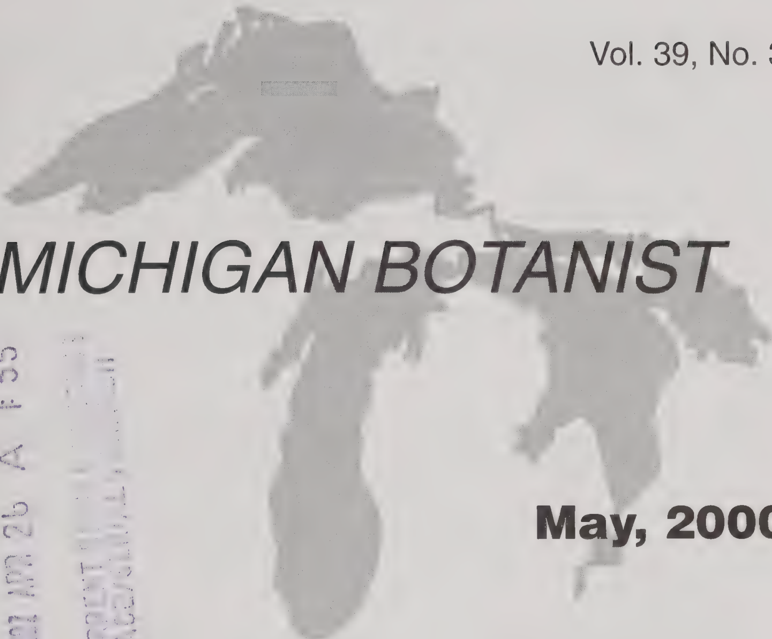
On the Cover: Aleurodiscus oakesii *(Berkeley et Curtis) Hohnel et Litsch, Basidiomycetes: Corticiaceae. Macroscopic appearance: A thin mat may cover an entire branch or tree or it may be patchy. As patches, the fungus appears as areas of discoloration and smoother than the normal bark. In moist weather, fruiting bodies appear on the mat that are 1–7 mm in diameter and of varied shape. The form is disc-like with inrolled edges. The underside is tomentose and grey. The upper side is fertile and of a buff-pink hue. Habitat: Usually on dead or dying trees that are not decorticated, less commonly on living trees. It is found on maples, birches, hornbeams, hickories, ashes, oaks, elms, and basswoods. A different species occurs on conifers. It ranges from Canada to Arizona, east to Alabama and Georgia. Microscopic: Basidia without clamps, moniliform cystidia with monomitic hyphal system. Basidiospores are 25–30 × 22–25 µm, covered with blunt spines. This organism is very common in Michigan and generally goes unnoticed unless there is marked contrast between the mat and the bark it covers. Apparently a saprophyte.*
Photo and caption courtesy of J.W. Rippon.



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EFFECTIVENESS OF HAND-PULLING THE INVASIVE MOSSY STONECROP (SEDUM ACRE L.) FROM ALVAR PAVEMENTS

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ABSTRACT

The Eurasian weed mossy stonecrop (*Sedum acre* L.), a tiny succulent plant of the Crassulaceae, is present on some alvar pavements on Manitoulin Island, Ontario. This study examined the rate of spread of mossy stonecrop on alvar pavement, and tested whether hand removal of stonecrop would eradicate the weed or possibly cause an increase in regrowth of it or other weeds. The study also looked at regrowth of mossy stonecrop in situ from fragments. Nine 1 × 1 m plots were given three different treatments: no pulling; careless pulling leaving fragments; very careful pulling leaving no fragments. Plots were observed for three growing seasons after treatment. Results show stonecrop is capable of rapid, aggressive growth, but that this does not always occur. Stonecrops do regrow from fragments or possibly from root remnants. Careful pulling techniques resulted in almost no stonecrop regrowth after three growing seasons. No regrowth of other weed species occurred.

INTRODUCTION

Mossy stonecrop (*Sedum acre* L.), a common Eurasian weed, is a fibrous-rooted, much-branched perennial with stems 5–10 cm long and succulent leaves of 2–5 mm (Cronquist 1991). The plants are mat-forming in habit, with a few centimeters at the tip of each creeping stem becoming upright and fleshy (Figure 1). The upright stems support terminal, small, yellow flowers and eventually dry capsular fruits. The plant has been cultivated in many forms and is widely naturalized throughout North America (Voss 1985).

On Manitoulin Island, Ontario, mossy stonecrop is a common weed of pastures and open areas of shallow soil over flat limestone bedrock. In fact, the plant is able to grow on the surface of bare limestone in small patches of soil less than 1 cm deep (personal observation). Because it can tolerate such conditions, mossy stonecrop finds suitable habitat in rare alvar communities.

Alvars are open, treeless ecosystems based on horizontal limestone bedrock. The vegetation is usually dominated by graminoid herbs or dwarf shrubs. Soil cover is shallow and sporadic, making these ecosystems fragile end easily disturbed by soil displacement. Recent work has brought attention to the rarity of different alvar community types as well as to the high incidence of rare species present on alvars (Brownell & Riley 2000; Reschke et al. 1999; Catling 1995; Catling & Brownell 1995).

Efforts to protect high quality examples of alvar require long-term management strategies that include plans to cope with threats. Thus, questions have been

FIGURE 1. Mossy stonecrop (*Sedum acre* L.).

raised about the invasiveness of mossy stonecrop on alvar: whether it spreads rapidly, whether it excludes native plants from using a portion of the habitat, and whether the disturbance caused by its removal would increase renewed growth of stone crop or other weed species. Work on common St. John's wort (*Hypericum perforatum* L.) by Stephenson (1995) in the alvar grassland of Maxton Plains, Drummond Island, Michigan, showed that hand pulling was ineffective for that species since plants from seeds stored in the soil more than replaced pulled plants.

There were additional concerns about pulling mossy stonecrop that didn't occur with other weeds in other situations. For instance, mossy stonecrop roots are thread-like, can be >10 cm long, and are difficult to remove in their entirety because they break. In addition, because the plants grow in areas of such shallow soil, it was thought that hand pulling to remove them might do more damage from soil displacement than good. As well, like most members of the Crassulaceae, mossy stonecrop fragments very readily and easily regrows from both leaf and stem fragments (personal observation). Thus, hand pulling might accidentally increase plant dispersal and regrowth.

The selective use of herbicide was not considered as a control method because stonecrop occurs in small, shallow pockets of soil sitting on impervious bedrock. This and the small stature of the weed would make it nearly impossible to prevent the herbicide from pooling on the surface of the rock and affecting other plants.

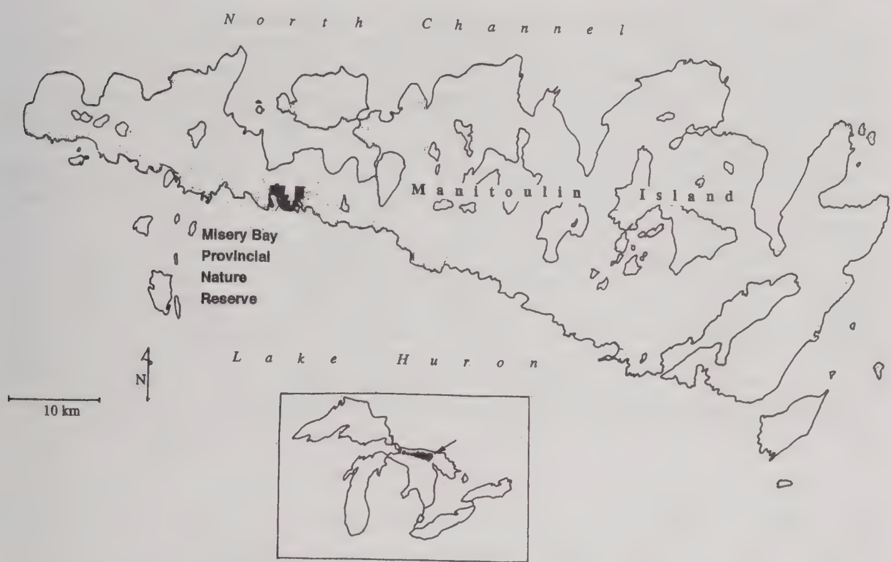

FIGURE 2. Location of Manitoulin Island and Misery Bay Provincial Nature Reserve.

Misery Bay Provincial Nature Reserve (45° 47′ N 82° 45′ W; Figure 2) is an 880 hectare provincial park which includes approximately 80 hectares of alvar vegetation (Jones 2000). Mossy stonecrop is present in several places in a variety of alvar vegetation types at Misery Bay. Park management expressed concern about the spread of mossy stonecrop within park alvars as early as 1994 when initial park planning documents were being drafted (Will Kershaw, Ontario Parks, pers. comm.), but an action plan on the weed's removal was delayed until the effects of pulling it could be studied. This current study looked at the degree of spread of mossy stonecrop on the alvar at Misery Bay Provincial Nature Reserve, its regeneration from fragments, and the effects of hand pulling on the population of stonecrop and other weeds.

METHODS

Nine permanent 1 × 1 m plots were laid out in an area of alvar pavement near the Lake Huron shore. To make the plots inconspicuous, only the corners were flagged. During monitoring, meter sticks were placed along the 4 sides of the plots.

Before any weed removal was done, each plot was sketched and photographed, and an estimate of the percent cover of stonecrop present in each plot was made using the meter sticks as a scale. The number of clumps of stonecrop was also counted. Mossy stonecrop was then pulled from the area 1m around the outside of all plots, to prevent any immediate reseeding or recolonization from fragments outside plot boundaries.

Three sets of three replicate plots were created. Each set was given a different treatment. The first treatment ("C plots") was a control in which no pulling or other action was done. The second treatment ("F plots") was hand pulling in a careless fashion, such as might be done by an unconcerned worker, intentionally leaving behind a small number of fragments at documented points. The third

treatment ("E plots") was hand pulling with extreme care leaving behind no known fragments in the best attempt at eradication . The technique was such that the fingers surrounded the clumps and reached under the plant so that most fragments remained in the hand while the other hand was held underneath the first hand to catch anything which fell out. All removed plants were carefully placed in plastic bags, removed from the park and composted. F and E Plots were photographed again following stonecrop removal.

Set-up took place in early July, 1998, with some plants in flower or young developing fruit but before fruit maturity. Soil was powdery dry although the plants appeared turgid. No other weed species was observed in the area.

The first monitoring took place September 18, 1999 (a little more than one year after the set-up of the experiment) after two growing seasons. Monitoring consisted of estimating the percent cover of mossy stonecrop, counting the number of clumps of it in the plot, sketching the location of the clumps in the plot, and photographing the plot. Notes were also made of any presence of other weeds in the plot. A second monitoring took place August 21, 2000 (a little over two years after the initial set-up) after three growing seasons. The weed-free 1 m zone around all plots was maintained at each monitoring. It is intended that this study will continue for several more years.

RESULTS

Table 1 shows some of the changes in the 9 plots over three growing seasons.

Control plots showed little net increase in percent cover or number of plants in three growing seasons. The number of plants in C2 increased with a high number of new single stems, but these are small in size and thus did not result in an increase of percent cover of stonecrop. Similarly, in C3 an increase in the number of tiny new single stems was off-set by a major die-back of larger clumps resulting in a net reduction in percent cover of stonecrop. In fact, the overall condition of the control plots after three seasons of growth was a major die-back of large clumps with only a few areas supporting new, tiny, single stems.

The first fragmentation plot, F1, showed no renewal of mossy stonecrop at all during the course of the three growing seasons, and no other weeds became present. The second fragmentation plot, F2, had two small clumps of mossy stonecrop present at the second monitoring, both were present at locations where fragments had been left. The clumps were small, one having 2 branches, the other with 9 branches, probably indicating one year's growth. There was an overall net loss of percent cover and number of clumps of stonecrop. These clumps were removed using the most careful technique, and the F2 plot was completely stonecrop-free at the end of the second growing season in 2000 (Figure 3).

Fragmentation plot F3 had no stonecrop present at the end of the second growing season. However, at the end of the third growing season, in 2000, one clump of mossy stonecrop was present beside and reaching underneath a large boulder. This was a location where fragments had been left after the initial treatment in 1998. This clump was removed in 2000 with the most careful technique.

Eradication plots E1 and E3 showed no renewed presence of mossy stonecrop at the end of 1999 or 2000. Plot E2 had one new, tiny stem present at the end of 1999 growing out of a dense patch of creeping juniper (*Juniperus horizontalis*

TABLE 1. Changes in nine plots over three growing seasons. C plots are controls which had no pulling. F plots had some fragments left behind in the first treatment. E plots had complete eradication attempted. Any stonecrop found in 1999 in F or E plots was removed using the most careful pulling techniques.

	number of clumps			percent cover		
Plot name	initial	1999	2000	initial	1999	2000
C1	25	~25	24	5%	5%	3%
C2	33	41	40	7%	7%	8%
C3	5	21 mostly tiny new stems	15	5%	3%	4%
F1	4	0	0	0	0	0
F2	6	2 new stems	0	0	<1%	0
F3	2	0	1	0	0	<1%
E1	3	0	0	0	0	0
E2	5	1	0	0	<1%	0
E3	2	0	0	0	0	0

Moench). This stem was removed with the most careful technique. At the end of 2000, all E plots were completely free of mossy stonecrop.

As well, no new presence of any other weed species occurred. On the other hand, new colonization by the native species rock sandwort (*Minuartia michauxii* (Fenzl)Farw.) was noted at three spots in plot F2 in 2000.

DISCUSSION

In fragmentation plot F3, it is unclear how the regrowth of mossy stonecrop occurred. The location of the clump coincides with fragments left at the initial pulling, making it highly likely that the re-growth occurred from fragments, but it is puzzling why growth was seen at this location in the third growing season but not in the second. It is not known if the fragments survived a season without growth, whether they were inconspicuous in the first year, or whether the clump regrew from roots remaining from the initial pulled plants. This requires further study.

The tiny stem present in the creeping juniper (*Juniperus horizontalis* Moench) in plot E2 is probably from a fragment that was overlooked in the first treatment because it fell into the crevices of the shrub. Still, it could also be from a root fragment or from outside dispersal.

Observation of the three control plots for three growing seasons portrays the degree of spread of mossy stonecrop on alvar to be a very slow process, interrupted by major die-backs, and which could hardly be termed aggressive or invasive. However, the explosion of a large (300 cm^2), completely new patch of stonecrop in the removal zone adjacent to control plot C2 (Figure 4) demonstrates that the species is capable of rapid growth. Observations on the rate of spread of mossy stonecrop remain inconclusive, but the observed potential for occasional rapid growth remains a concern. Further work is needed to shed light on the conditions which allow such rapid and potentially invasive growth.

FIGURE 3. Plot F1 before pulling (above) and after three growing seasons in 2000 (below). No mossy stonecrop is present in 2000.

Results from the fragmentation plots show that it is highly probable that mossy stonecrop can re-grow from fragments, although there is a small possibility that the re-growth could have been from root remnants unknowingly not removed. Yet, from a pragmatic point of view, even with the re-growth, the net result is a reduction in the percent cover and number of clumps of mossy stonecrop. This means that even if alvar managers must rely on careless volunteers to pull the stonecrop and are then required to go out and pull again for a second season or perhaps additional seasons, the subsequent efforts should require much less time and effort. The initial results of this study show that in spite of the small number of renewals of mossy stonecrop, the net result of hand pulling is a major reduction in the presence of the weed.

Results from the eradication plots show that careful pulling can very nearly eliminate mossy stonecrop, so ideally workers pulling the plants should use careful technique and vigilantly remove any fragments that get dropped.

None of the plots showed any new growth of other weed species, but the location of the plots is virtually free of other weed species. Therefore, this experiment is not a good test of the effects of soil disturbance from pulling stonecrop on the regrowth of other weeds. The new growth of the native rock sandwort in plot F2 could perhaps point to an example of stonecrop filling a niche which would normally be occupied by a native alvar species. It is possible that soil disturbance from weed removal may even have helped the rock sandwort get established.

FIGURE 4. A very large patch of mossy stonecrop (adjacent to Plot C2) which grew to this size in a single year. The rapid growth of this patch suggests the species is capable of aggressive spread, despite the fact that this was not demonstrated in the control plots.

CONCLUSIONS

The initial results of this long-term study show that mossy stonecrop may be hand pulled from alvar habitats with little regrowth. It is suggested that limited hand pulling be initiated in a wider but controlled area which will be monitored. The potential for trampling of the habitat by workers must be addressed, and care should be taken as it is not known if walking on mossy stonecrop could affect dispersal or re-growth.

ACKNOWLEDGMENTS

Thanks to the Friends of Misery Bay and Ontario Parks for providing access to the study site at Misery Bay Provincial Nature Reserve. Thanks to Steve Hall for field assistance.

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THE BIG TREES OF MICHIGAN
26. Acer pseudo-platanus L.
Sycamore Maple

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Michigan's largest known Sycamore Maple stands on the grounds of the Lake Bluff Audubon Center near Manistee, Manistee County, MI, on the western side of the lower peninsula.

Description of the Species: The Sycamore Maple is a member of the family Aceraceae, along with the Box Elder and a number of other maples, both native and introduced. Characteristics it shares with these include opposite, palmately lobed, simple leaves (only the Box Elder among our maples has compound leaves) and its distinctive paired samaras, the diagnostic fruits of maples. The Sycamore Maple can be distinguished from other members of the genus *Acer* by having bright green winter buds. Its leaves are 4–7″ across, 5-lobed, and bluntly toothed (Fig. 1). The samara wings are 1.5–2″ long, diverging at right angles or less.

Acer pseudo-platanus is a native of Eurasia. It is infrequently planted across much of eastern North America, usually in botanical gardens and arboreta and on college and university campuses. It is rarely used as a street tree.

Location of Michigan's Big Tree: The tree is located on the grounds of the Lake Bluff Audubon Center near Manistee, Michigan. To reach the tree, take U.S. Route 31 north from Manistee. Where MI Route 110 turns to the left and U.S. Route 31 continues to the northeast, turn left onto MI Route 110. The Lake Bluff Audubon Center is on MI Route 110, 1.8 miles from its junction with U.S. Route 31. The tree is immediately behind the headquarters building of the Lake Bluff Audubon Center.

Description of Michigan's Big Tree: The tree is healthy, with a solid, sound trunk. It was measured on 26 July 1995 by the authors. The girth at 4.5′ above the ground is 111″ (2.8 m). The tree is 53′ high (16.3 m), and has an average crown spread of 54′ (16.6 m).

INVITATION TO PARTICIPATE

If you would like to join us in extending this series of articles by visiting and describing one or more of Michigan's Big Trees, please contact Elwood B. Ehrle for help with locations, specifications for taking measurements, and assistance with the manuscript. The Michigan Botanical Club encourages your involvement in this activity. Please remember to ask permission before entering private property.

1. Winter twig, x 1.
2. Leaf, x ½.
3. Flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Perfect flower, enlarged.
6. Fruit, x ½.

FIGURE 1. Chacteristics of the Sycamore Maple. The illustration is from Otis, 1931, p. 222, and is used with permission.

DEDICATION

This series of articles is dedicated to the memory of Paul Thompson, Michigan's Big Tree Coordinator for over 40 years, who died in 1994.

LITERATURE CITED

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REVIEWS

WILDFLOWERS OF DOOR COUNTY [Wisconsin]. Paul and Marilyn Mahlberg. Indiana University Press. xxvii + 210 pp. Paperback; $15.16 plus shipping from amazon.com.

This guide covers 380–400 species of wildflowers, including some shrubs and woody vines. The authors are not professional taxonomic botanists and they are not addressing that audience. From the amazon.com site, I learned that as a teenager, Paul G. Mahlberg's decision to become a botanist was stimulated by summers at Door County's Kangaroo Lake. Now retired from the biology faculty at Indiana University in Bloomington, he continues to do research on secretion by plant cells. The artist, Marilyn Waite Mahlberg, is an active member of the Bloomington Area Arts Council in Indiana and the Peninsula Arts School in Door County. Since retirement she has devoted her efforts to oil painting and to ecological activities, with a particular interest in the preservation of ecologically important areas of Door County

The paintings are generally quite good and are faithful to the subject. The painting of *Castilleja coccinea*, however, is not accurate. It appears the artist misunderstood the arrangement of the bract beneath the calyx and how the calyx encloses most of the corolla. I hadn't known that *Cotoneaster divaricatus*, p. 130, widely planted around homes in Wisconsin, escaped into woodlands. The plant is of the Rosaceae, in any case, not of the Ericaceae as given in the book. That the species is introduced is not mentioned, either. The plant is not mentioned on the website where one can check such details, wiscinfo.doit.wisc.edu/herbarium/index.

Comandra umbellata, Bastard Toad-flax, is nicely described and illustrated on p. 93. However, its fruit is described as a juicy drupe, which would make it *Geocaulon lividum*, a rarity in Wisconsin known only from Door County. One cannot be sure what's what.

Valeriana officinalis is a well-established escape in the state; the book, however, makes no mention of this roadside element, and treats only *Valeriana uliginosa*, which is a rarity in Wisconsin and not given for Door County on the website cited above (nor is *V. officinalis*, comes to that, though I have two specimens of it from Door County in herb. OSH). Nonetheless, for the plant pictured the basal leaves are described as deeply pinnate, with 5–8 pairs of leaflets, which would make it *V. officinalis*. I am not sure what's going on here.

Clearly, the book cannot be thought of as any kind of "checklist" for the county. There are apparently vouchers deposited in WIS, or so the introductory material implies. In any case, readers should be warned not to work backward from the book to reality. However, if you see a big cut-leafed teasel along the roadside outside of Sturgeon Bay, and if you work through this book (no keys, but the plants are grouped by flower color), you will get the name for your plant, *Dipsacus laciniatus*. You can look elsewhere for the authors of the binomials; none are given here.

Just before the ample index (to both scientific and common names), there's a bibliography, even though no books are cited within the body of the book. It includes what you would expect, including Rabeler's *Gleason's Plants of Michigan*; but it excludes such obvious works as Case's *Orchids of the Western Great Lakes Region*. Voss' *Michigan Flora* got no mention, either.

Door County, Wisconsin, is one of the state's major tourist playgrounds. One can expect that this book will enjoy steady sales at dozens of local establishments. Royalties go to the Door County Land Trust, so it is all in a good cause.

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RAMBLINGS: REFLECTIONS ON NATURE. Emma Bickham Pitcher. 2001. Beach Leaf Press. Kalamazoo, Michigan. Order from Kalamazoo Nature Center, P.O. Box 127, Kalamazoo, MI 49004. Total cost including Michigan Sales Tax and shipping and handling: U.S. $16.17. 318 pages. ISBN: 0-939294-19-2.

For researchers tired of cataloging correctly spelled scientific names and documenting statistical data, Emma Bickham Pitcher's new book (released 3 June 2001) makes delightful bedtime reading, giving one a chance to "de-program" the brain from technical to relaxing nature thinking before sleep. As a co-member of Michigan Botanical Club, I have been fortunate to get to know Emma on MBC Forays and Christmas pot-luck suppers. This thoroughly enjoyable octogenarian is one of the truly amazing naturalists I am privileged to know, (and probably never will be included among). She is knowledgeable about not just one or two specialties, but the entire gamut of natural history.

Like many accomplished naturalists, Emma did not spend her working career as one. After retirement as Dean of Students at the Graduate School of Business at the University of Chicago and raising a family, she moved to Michigan where she combined her interests with the need for volunteers at the Kalamazoo Nature Center. The essays in this and her previous book *Of Woods and Other Things,* were first published as columns supplied by the Nature Center to the Kalamazoo Gazette. She has also published *Up and Down the Dunes.* Her most recent book is another good example of this broad spectrum of expertise.

Her Ramblings" essays are divided into sections: "About Birds," 19 essays; "About Trees," 12 essays; "About Blossoms," 12 essays; "Out and About," 18 essays. One area she is expert on is arctic plants, since she spends part of each summer within a few miles of the Arctic Circle. "Life at 62 degrees, 5 minutes North" describes some of the coping strategies evolved by plants in this harsh environment. At a MBC Spring Foray a few years ago, she did a program "What a Belly Botanist Learns," which described how she examined and photographed

the minute arctic blossoms—prone. A student, sponsored for the Foray experience by one of the club's chapters, commented on the evaluation form, that Emma Pitcher's program epitomized what nature education should be like. In "About trees," she discusses spring time trees, dogwoods, willows, white pine, ginkgo, and topics such as bird trees, autumn, seeds, winter identification. "About Blossoms" includes Blue, Color Me Yellow, Orange, Pale Pink, and bogs and fens. "Out and About" touches on nature in winter, among other topics.

It is easier to find spring, summer, and autumn happenings in nature. Winter can appear to be a "dead" season, but Emma finds several interesting aspects to write about. Orange flowers include Butterfly Weed, one of the milkweeds, and yellow fringed orchids, a plant Emma claims are "misnamed plants that are truly orange." Jewelweed and native lilies also fall into this color category. Dandelions, daffodils, and spice bush show how blossoms of one color, in this case yellow, can run the gamut from aliens that are despised by many to those beloved by many, to a native that is especially favorable to many species of birds.

Blue-eyed Mary, Virginia Bluebells, forget-me-nots, great blue lobelia, and the alien chicory are some of the "blue," but not depressing, blossoms she describes. Emma even explains ways that "black" occurs in nature.

Her last paragraph seems especially suitable for ending her book and the year: "Relive your happiest nature moments and resolve to fill the new year with them. Ravine and ridge, dune and swale, field and forest, river and stream are out there awaiting your open mind and heart."

Although the essays themselves use primarily common names, there is a "Common and Scientific Names" listing in the back of the book, along with a complete index to species and topics. The book is illustrated with scratchboard drawings by Elizabeth Henderson.

—Betty J. Mattson
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CONTENTS

On the cover: *Flowering twig of Juglans nigra L., the black walnut, photographed by Thomas G. Lammers in Whetstone Park, Columbus, Ohio, 24 May 1986.*

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THE MICHIGAN BOTANIST

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Articles dealing with any phase of botany relating to the Great Lakes Region may be sent to the Editor at the address above. In preparing manuscripts, authors are requested to follow our style and suggestions in "Information for Authors": (volume 28, p. 43; volume 29, p. 143), **except** please omit all abbreviations in journal and book titles. Smaller contributions not involving illustrations may be submitted as e-mail attachments (indicate format, preferably WordPerfect, DOS or Windows) or incorporated into the body of an e-mail.

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THE SAND CHERRY IN WISCONSIN AND NEIGHBORING STATES

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A recent paper on the sand or dwarf cherries by Catling, McKay-Kuja, & Mitrow (1999) prompted my reëxamination of these plants in Wisconsin and neighboring states. I had previously examined specimens of sand cherries from across their range in North America as part of my treatment of *Prunus* for the Flora of North America project. Historically, botanists have been divided on how best to treat taxonomically the variation among sand cherries. Those from the late nineteenth and early twentieth centuries who specifically studied the genus *Prunus* (Bailey 1892, 1894; Wight 1915; Fernald 1923) ultimately split the sand cherry into four separate species: *Prunus besseyi* Bailey, *P. depressa* Pursh, *P. pumila* L., and *P. susquehanae* Willd. (= *P. cuneata* Raf.). Yet others had doubts as to whether the variation warranted recognition at the species level. For example, Groh & Senn (1940: 328) wrote, "We are unable to follow Fernald in recognizing as distinct species the three sand cherries of Eastern Canada. . . . These entities show a complex series of intergradations in the morphological characters which Fernald uses to separate them. . . . Additional collections seem to be rapidly destroying any supposedly definite boundaries between these forms. Consequently since there is considerable intergradation in morphological characters and not too sharply delimited geographical ranges we consider that these sand cherries should be regarded as varieties of a polymorphous species rather than as distinct species." In the two great mid-twentieth-century floras for the northeastern quarter of the United States and adjacent Canada, Fernald (1950) maintained four species of sand cherry, whereas Gleason (1952) recognized four varieties of a single species (*Prunus pumila s.l.*).

More so than those from other regions, Midwestern botanists had great difficulty in sorting the local variation among sand cherries into the distinct species of Fernald (or the varieties of Gleason). Deam (1940: 580), working on the flora of Indiana, stated, "*Prunus cuneata* and *Prunus susquehanae* are named forms of *Prunus pumila* which I do not regard as of taxonomic value." In Michigan Flora, Voss (1985: 370) called the sand cherry, "a variable species, the extremes distinctive but thoroughly intergrading." The situation is similar in Wisconsin, where Mason & Iltis (1958: 91) commented "*Prunus pumila, sensu lato*, is very variable in Wisconsin, with only the extremes separable into the above-named forms [*P. pumila* and *P. susquehanae*]. In plotting the length vs. width of leaves of all Wisconsin collections, it is clear, however, that the extremes are at either end of a continuous variation pattern. Since most specimens fall between the

above named morphological extremes, they cannot be assigned to one or the other of the varieties or species. For this reason the segregate taxa are not recognized here. A detailed study of this species throughout its range would seem highly desirable."

Catling and his colleagues (1999) introduced a new character, pubescent twigs, by which *P. susquehanae* could be distinguished from other members of the sand cherry complex. As a result they recognized two species: *P. susquehanae* and *P. pumila*, the latter with three varieties. In pursuing this study I had several questions in mind. By using this new character, could some sense finally be made of the variation in sand cherries in Wisconsin, Michigan, and Indiana, where before intergradation in other characters had led to the recognition of a single variable species? If species or varieties can be recognized in the Midwest, which characters are most useful? What are the geographic distribution and ecological habitat of each taxon? And, why did Midwestern botanists seem to have more problems with recognizing species or varieties of sand cherry than Eastern botanists?

VARIATION IN KEY MORPHOLOGICAL CHARACTERS

Twigs

Indeed, pubescence on the twigs seems to be the key to solving much of the puzzle of variation in Midwestern sand cherries. The hairs are so short as to be imperceptible to the unaided eye and magnification of at least 10× is required. As much as I hoped that all twigs would be either densely puberulent or glabrous, thus allowing me to easily segregate species as Catling et al. (1999) suggested, this was not the case. About 8% of the specimens that I examined had a sparse pubescence on the twigs, quite unlike the dense minute pubescence illustrated by Catling et al. Many of these specimens were from the Great Plains where all floras list *P. besseyi* as the only indigenous sand cherry. Based on their other characters, these specimens are clearly *P. besseyi*. Thus the presence of any hairiness on the twig cannot be used definitively to identify *P. susquehanae*. To further complicate the picture in the Midwest, there were a few specimens from northern portions of Minnesota, Wisconsin, and Michigan, that although they had glabrous twigs, seemed to otherwise fit the description of *P. susquehanae*. All specimens of *P. pumila s.s.* examined had completely glabrous twigs. The same was true for *P. depressa* with the exception of two specimens that otherwise had the characters and habitat of *P. depressa*.

Habit

Sand cherries are shrubs, commonly less than a meter in height, but potentially up to 2.5 m high in plants of the Great Lakes sand dunes. The posture of the major stems, whether erect, ascending, decumbent, or prostrate, has been of great importance in separating the four taxa. *P. depressa*, as its name suggests, is best defined by its prostrate habit. The main stems lie flat on the substrate and

radiate outward with the erect branches forming a low mat, no more than half a meter in height. The other three taxa typically have erect or at least ascending stems. However, in each it is not unusual to find some decumbent or prostrate stems in the same colony as erect-ascending stems, thus leading to the plant's potential misidentification as *P. depressa*. I am convinced that *P. depressa* is an eastern entity, not found in Wisconsin or its neighbors, and that reports of *P. depressa* from Wisconsin almost certainly are based on decumbent or prostrate plants of *P. pumila*.

Leaves

Overall leaf shape, blade length-to-width ratio (l/w), and shapes of the blade apex and base have been widely used to distinguish the four sand cherry taxa. In addition, differences in blade width, thickness, color, and serration have been used in keys, and differences in the lengths of petioles and stipules implied in descriptions. Many of these characters, such as sharpness of serrations, thickness, and paleness of the lower leaf surface, are qualitative or difficult to measure with precision. For instance, in his key Fernald (1950) used the texture descriptors "subcoriaceous," "firm-membranous," "becoming coriaceous," and "submembranaceous" to distinguish among *P. pumila*, *P. susquehanae*, *P. besseyi*, and *P. depressa*, respectively. Although most leaves of *P. besseyi* are noticeably thicker than those of *P. depressa* when the two are compared side by side, when identifying a single specimen of sand cherry it is difficult to be certain whether the better choice in the key might be "subcoriaceous" or "becoming coriaceous." Among the sand cherries leaf thickness and texture vary continuously from that typical for a temperate-zone plant to decidedly thicker and somewhat leathery. The same continuous variation is seen in most of the other qualitative leaf characters.

Characters that can be quantified, and thus tested statistically, are leaf lengths and widths, as well as the ratio between them. Three mature leaves from each of 127 specimens from Wisconsin and 207 specimens from other states were measured for length and width and then averaged per specimen and analyzed (Table 1). Leaves of *P. depressa* are typically oblanceolate with an obtuse or less commonly acute apex. They are longer on average than leaves of the other varieties

TABLE 1. Mean, (median), and standard deviation for length, width, and length-to-width ratios of leaves for each taxon of sand cherry. n = number of specimens from which three leaves were measured and averaged.

Taxon		n	Length (cm)	Width (cm)	L/W Ratio
besseyi	Wisconsin	41	4.98 (5.07) ± 0.95	1.74 (1.80) ± 0.42	2.94 (2.81) ± 0.48
	Elsewhere	86	4.40 (4.37) ± 0.82	1.57 (1.57) ± 0.34	2.86 (2.81) ± 0.36
depressa	Elsewhere	22	5.38 (5.38) ± 0.96	1.47 (1.43) ± 0.25	3.70 (3.69) ± 0.48
pumila	Wisconsin	34	4.90 (4.90) ± 0.90	1.53 (1.55) ± 0.36	3.29 (3.24) ± 0.58
	Elsewhere	39	4.63 (4.63) ± 0.67	1.41 (1.37) ± 0.28	3.36 (3.28) ± 0.54
susquehanae	Wisconsin	52	4.73 (4.80) ± 0.71	1.86 (1.87) ± 0.35	2.60 (2.54) ± 0.31
	Elsewhere	60	4.85 (4.87) ± 0.71	1.94 (1.95) ± 0.36	2.55 (2.49) ± 0.38

and are nearly always at least three times longer than wide, averaging 3.7:1. At the other end of the spectrum is *P. susquehanae* where 99 of the 112 specimens that I measured (88%) had a l/w ratio less than 3:1. Their leaves are elliptic to obovate with the apex generally obtuse but varying from acute to rounded. From Quebec and New England to southern Pennsylvania where these are the only taxa present, they are readily distinguished, perhaps explaining why Fernald and other Eastern botanists recognized them as distinct species.

Prunus pumila of the Great Lakes shores has leaves that are elliptic to oblanceolate, or sometimes obovate, usually with an acute apex. Although the keys of Fernald (1950), Gleason & Cronquist (1991), and Catling et al. (1999) give a l/w ratio of at least 3:1, 35% of the Wisconsin specimens that I measured and 26% of those from elsewhere had ratios less than that. The presence of *P. besseyi* in Wisconsin, Minnesota, Illinois, and Indiana further complicates using leaf measurements to distinguish the varieties. The l/w ratio of *P. besseyi* is intermediate between *P. pumila* and *P. susquehanae*, averaging 2.9:1. Although the leaves of *P. besseyi* from the Plains States are distinctly smaller, in Wisconsin and its neighbors they are of comparable size and shape to other sand cherries. They can be elliptic, oblanceolate, or obovate in outline with an acute, short acuminate, or obtuse apex. Unfortunately a sand cherry collected from Wisconsin with leaves averaging 4.9 cm long by 1.7 cm wide (l/w = 2.88) could be any one of our three taxa.

I also did a preliminary analysis of petiole and stipule lengths, but abandoned a fuller study when the means and ranges were similar among the four taxa.

Fruits

Fruits are described as varying meaningfully in size and taste, as well as in the size and shape of the pit. Fernald (1923, 1950) described the taste of *P. depressa* as acid, but of rich quality, more palatable than those of *P. pumila*, which he called astringent. Those of *P. besseyi* he reported as sweet and fleshy. I have tasted fruits of the three taxa found in Wisconsin, and the only conclusion I could draw is that fruit taste varies considerably, even among fruits of the same shrub and certainly within the same taxon. Mature fruits of *P. besseyi* do seem to be slightly larger, on average, than those of *P. pumila* and *P. susquehanae*, but I did not measure fresh fruits from enough wild populations to make a definitive statement. More than the other taxa, *P. besseyi* has been cultivated for its fruits, and this may explain why some literature sources attribute a significantly larger size to them. I have measured fresh mature fruits of *P. pumila* from 8 to 15 mm in diameter, thus linking the size given by Fernald's key (1950) for *P. pumila* with that of *P. besseyi*. Herbarium specimens cannot be used to measure fruit size. Either the mature fruits are smashed flat, thus inflating their size, or they have been dried without pressing and have shrunk. I measured ten fresh mature fruits of *P. pumila* and then dried them without pressing and measured them again. On average they decreased 17% in length and 30% in width. Pit size and shape can be reliably measured from herbarium specimens, but most specimens lack pits. I was able to collect data from 80 specimens representing all four taxa (Table 2). Pits of *P. depressa* are distinctively narrower than others and are more fusiform

TABLE 2. Mean, (median), and standard deviation for length, width, and length- to-width ratios of pits for each taxon of sand cherry. n = number of specimens from which one to four pits were measured and averaged.

Taxon	n	Length (mm)	Width (mm)	L/W Ratio
besseyi	22	8.0 (8.0) ± 0.9	6.2 (6.3) ± 0.8	1.30 (1.29) ± 0.09
depressa	9	7.3 (7.4) ± 1.1	4.9 (4.9) ± 0.6	1.50 (1.50) ± 0.14
pumila	24	8.4 (8.2) ± 0.7	6.2 (6.1) ± 0.5	1.35 (1.33) ± 0.14
susquehanae	25	7.4 (7.5) ± 1.0	5.7 (6.0) ± 0.6	1.30 (1.30) ± 0.17

in shape. Otherwise I question the usefulness of pit length or width as a key character. Pits of *P. susquehanae* are somewhat shorter and narrower on average than those of *P. besseyi* or *P. pumila*, but there is too much overlap for this character to be useful in determining most specimens. I could not see any significant difference in the overall shape of their pits or the shape of the pit apex or base. There was simply too much variation, from nearly globose to ovoid stones, within each taxon.

TAXONOMIC CONCLUSION

After studying the literature and many specimens, as well as comparing variation in the sand cherry with taxonomic concepts in other North American species of Prunus such as *P. serotina*, my conclusion is to recognize one species of sand cherry, *P. pumila*, with four varieties (*besseyi, depressa, pumila*, and *susquehanae*). Although I agree with Catling et al. (1999) that the four sand cherry taxa are not equally distinct, as might be suggested by recognizing either four species or four varieties of a single species, I do not think that the differences between *P. susquehanae* and the other three taxa warrant their recognition as two species. The only morphological character separating *P. susquehanae* from the three varieties of *P. pumila* is pubescent twigs; in all other characters the range of variation in *P. susquehanae* broadly overlaps (much more than keys indicate) the variation seen in one variety or another of *P. pumila*. A reasonable, but also more cumbersome, taxonomic solution would be to recognize a single species with two subspecies: *P. pumila* subsp. *susquehanae* and *P. pumila* subsp. *pumila*, the latter with three varieties (*besseyi, depressa*, and *pumila*). (I do not accept these combinations, and explicitly disavow any intention of creating them.) Cochrane & Iltis (2000) have argued that the sand cherry is "a complex species of East-West ecotypes centered on two unglaciated survivia:" a short-leaved western ecotype (var. *besseyi*) from the Great Plains and a long-leaved eastern ecotype (vars. *depressa, pumila*, and *susquehanae*) from the Pennsylvanian Appalachians. If they are correct, then var. *besseyi*, rather than var. *susquehanae*, would be the more distinct taxon, at least evolutionarily. They state that "Wisconsin specimens exhibit thoroughly intergrading morphological variation" from one ecotype to the other. And, indeed they do. Yet even though the morphological characters show almost continuous variation, the differences in eco-

logical habitat and geographical range among the taxa argue for their recognition at some taxonomic rank. Until further research can illuminate the evolutionary relationships among these four taxa and the degree of gene flow among them, I believe the best solution is to stick with four taxa of equal rank within one variable species.

KEY TO SAND CHERRIES OF THE UPPER MIDWEST

Twigs of the current year densely and minutely pubescent (examine with at least 10× magnification); leaf blades often obtuse at apex and mostly 2.2–3.0× longer than wide; inhabiting open pine woods or barrens, or nearby sandy fields and roadsides across northern Minnesota and Wisconsin as well as much of Michigan south to Indiana . . . . *P. pumila* var. *susquehanae*

Twigs of the current year glabrous or rarely sparsely pubescent; leaf blades often acute at apex and mostly more than 2.5× as long as wide; inhabiting prairies, or shores of the Great Lakes.

Shrubs growing on prairies and nearby roadsides or on rock outcrops from northern Indiana and Illinois west to the Great Plains; leaf blades mostly elliptic to obovate, averaging 2.9× longer than wide . . . . . . *P. pumila* var. *besseyi*

Shrubs growing on or near shore of the Great Lakes, typically on sandy beaches, dunes, or flats, much less commonly on rocky shores or pavements; leaf blades mostly oblanceolate, averaging 3.3× longer than wide . . . . *P. pumila* var. *pumila*

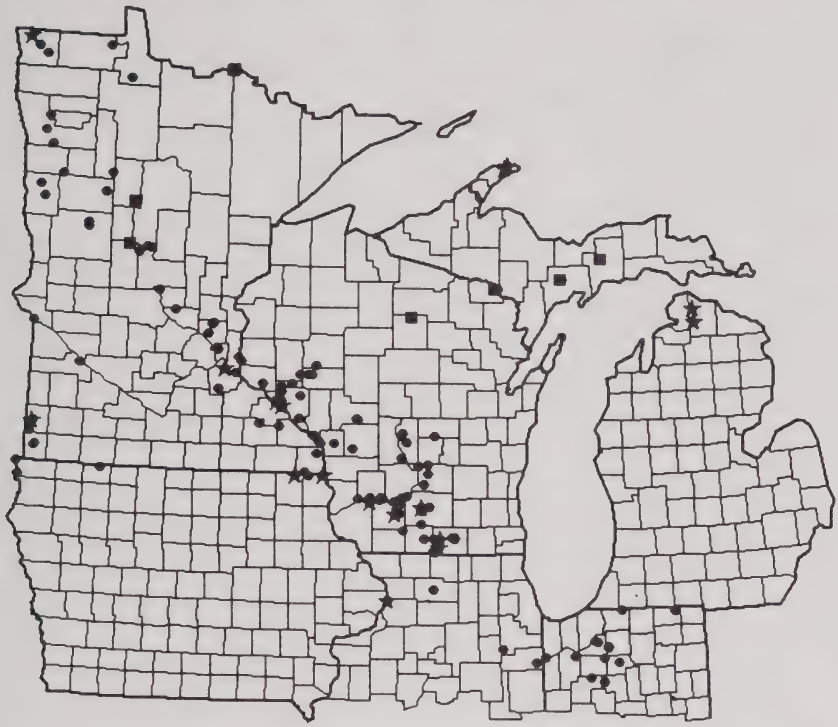
SYNOPSIS OF MIDWESTERN SAND CHERRIES

Each variety is mapped for Wisconsin and neighboring states with a description of its broader distribution. Notes on habitats and the list of common associates are based on the occurrence of sand cherry in the Midwest as gathered from specimen labels and personal field experience. See Catling et al. (1999) for a review of synonymy and typification of names.

Prunus pumila var. *besseyi* (Bailey) Waugh—Western Sand Cherry

Distribution: Map 1; Manitoba south across the Great Plains to Colorado and Kansas, southeast to the northern regions of Illinois and Indiana. Occasional plants are found as far east as Michigan, Ohio, and southeastern Ontario.

Habitat: Prairies and relict oak savannas over sandy soil along rivers, railroads, and highways; rocky or sandy south- to west-facing hillside "goat prairies"; sandstone or limestone outcrops, ledges, or ridges; and occasionally in open jack pine or scrub oak forests and barrens. Across the Great Plains it is typically on sand hills and a component of the dry, short-grass prairie, but is also



MAP 1. Distribution of *Prunus pumila* var. *besseyi* in the Upper Midwest. Specimens with leaf l/w ratios ≥ 3.30:1 are indicated with a star; those within the range of var. *susquehanae* and with similar broad leaves but glabrous stems are indicated with a solid square.

found along the tops and dry slopes of limestone, sandstone, and quartzite ridges, outcrops, bluffs, and buttes.

Common associates: *Andropogon gerardii*, *Anemone patens*, *Bouteloua hirsuta*, *Coreopsis palmata*, *Euphorbia corollata*, *Geum triflorum*, *Lespedeza capitata*, *Liatris aspera*, *Selaginella rupestris*, *Solidago nemoralis*, *Sporobolus heterolepis*, *Schizachyrium scoparium*, *Tephrosia virginiana*.

Prunus pumila L. var. *pumila*—Great Lakes Sand Cherry

Distribution: Map 2; Along the shores of the Great Lakes from Minnesota and southwestern Ontario south to Illinois, Indiana, and Ohio; and east to New York and southeastern Ontario.

Habitat: Restricted to Great Lakes shores, mostly on sandy beaches, sand spits, sand dunes, and sandy ridges; less commonly on gravelly or rocky beaches. It also inhabits marshes in damp swales between dunes and on low sand flats, and is only occasionally found in open woods on older dunes and sandy prairies near the lakeshore.

Associates: *Ammophila breviligulata*, *Arabis lyrata*, *Arctostaphylos uva-ursi*,

MAP 2. Distribution of *Prunus pumila* var. *pumila* in the Upper Midwest.

Artemesia campestris, Calamovilfa longifolia, Cirsium pitcheri, Elytrigia dasystachya var. *psammophila, Hudsonia tomentosa, Juniperus communis, Lathyrus japonicus, Schizachyrium scoparium, Tanacetum huronense*.

Prunus pumila var. *susquehanae* Willd.—Appalachian Sand Cherry

Distribution: Map 3; Minnesota and southwest Ontario east to Maine, south to Wisconsin, Indiana, and in the Appalachian Mountains and Piedmont to New Jersey and Pennsylvania, with outlying populations in Virginia, North Carolina, Tennessee, and Arkansas.

Habitat: Strongly associated with pine, typically growing in dry sandy soil under an open canopy of jack pine often mixed with northern pin oak. Today it can also be found in areas lacking pine, such as sandy fields, barrens, and roadsides, where the original vegetation was a jack pine forest or barrens. In Wisconsin this variety is almost exclusively found on the excessively drained sandy soils of soil region "C" in the central part of the state and region "H" in the northern part. These soils formed on glacial outwash plains and in the bed of glacial Lake Wisconsin. Variety *susquehanae* also inhabits sandy and rocky shores of rivers and lakes, and establishes itself on the shallow sandy soils on sandstone cliffs and ledges. In New England and the mid-Atlantic States it oc-

MAP 3. Distribution of *Prunus pumila* var. *susquehanae* in the Upper Midwest.

cupies acidic sandy soils from dry mountain slopes to wet lakeshores and marshes.

Associates: *Arctostaphylos uva-ursi, Aronia melanocarpa, Chimaphila umbellata, Corylus americana, Comptonia peregrina, Epigaea repens, Gaultheria procumbens, Helianthemum canadense, Koeleria macrantha, Lithospermum canescens, Melampyrum lineare, Pinus banksiana, Pteridium aquilinum, Quercus ellipsoidalis, Vaccinium angustifolium.*

Prunus pumila var. *depressa* (Pursh) Bean—Prostrate Sand Cherry

This variety grows on rocky or sandy shores of rivers and lakes from Quebec's Gaspé Peninsula west to Lake Superior and south to Pennsylvania. It does not occur in Wisconsin or its neighbors, the possible exception being Drummond Island, Michigan. Plants from Wisconsin previously referred to this variety are decumbent or even prostrate forms of the other varieties, especially var. *pumila*. I have seen such plants growing on the dunes of Lake Michigan at Point Beach State Forest and at Kohler-Andrae State Park. Unfortunately, I have not searched Drummond Island, Michigan, from which I have seen herbarium specimens that were impossible to assign to either var. *depressa* and var. *pumila* with certainty. Variety *depressa* does occur on similar dolomite pavements nearby on Manitoulin Island, Ontario.

PROBLEMATIC SPECIMENS

Although progress has been made in clarifying the distribution and habitat of sand cherries in the Midwest, there are still specimens of uncertain affinity. About 10% of the specimens that I examined from across the geographic range of the sand cherry were difficult to identify because of incongruence between key characters. Most of these were from the Midwest. Indeed, it is not surprising that faced with these problematic specimens, Midwestern botanists often opted for recognizing only a single variable species without subspecific taxa. Below I describe some of the problems that remain in identifying sand cherries in Wisconsin and its neighbors.

Distinguishing var. susquehanae *from the other varieties*

Although var. *susquehanae* is morphologically the most easily distinguished of the four varieties, not all specimens examined had twigs that were either densely pubescent as in var. *susquehanae* or completely glabrous as in the other varieties. Some specimens had hairs that were sparse and even shorter than those of var. *susquehanae*. Based on leaf size, leaf shape, habitat, and locality, the majority of these specimens were determined as var. *besseyi*, but others were closer to var. *susquehanae*. It is possible that this intermediate pubescence is evidence of hybridization between these two taxa, especially in the Midwest where their ranges meet and overlap slightly.

Particularly problematic were specimens from the border between Minnesota and Ontario (especially around Rainy Lake) and scattered across northern Wisconsin and northern Michigan. Here dense twig pubescence shows only modest correlation with broader leaves and obtuse apices. Some specimens have pubescent twigs but elliptic leaves with acute apices; others have obovate leaves and obtuse apices but glabrous twigs. I mapped all of these specimens with glabrous twigs as var. *besseyi* (Map 1; solid squares). These and other eastern outliers from the main range of var. *besseyi* may be remnants from warmer and drier Pleistocene times. Or they may have been transported eastward by Native Americans at sometime in the past (Reznicek, 1983). It is possible that the broader leaves and blunt apices are evidence of gene flow from var. *susquehanae*. Or perhaps these are simply glabrous individuals of var. *susquehanae*.

Distinguishing var. besseyi *from var.* pumila

The morphological characters used to separate these varieties are overall leaf shape, apex shape, base shape, l/w ratio of the leaves, plant habit, and fruit diameter and taste. As discussed earlier these characters are either ambiguous or continuous between the varieties. In their key Catling et al. (1999) give clearly disjunct l/w ratios as a key character (leaves 3.3–10× as long as wide for var. *pumila* and 1.6–2.5× as long as wide for var. *besseyi*). Although I agree that leaf shape is the best morphological character separating the two varieties, my measurements indicated broad overlap between their l/w ratios. In fact, 61% of the 74 specimens of these two taxa measured from Wisconsin had leaf blades between 2.5 and 3.3× as long as wide, thus falling outside the range of values used

in their key to identify them. The average l/w ratio measured for leaves of var. *besseyi* both in Wisconsin and elsewhere was 2.89:1 (Table 1).

How then can these two varieties be distinguished? Determination of flowering specimens without leaves, and even many with leaves, was done on the basis of habitat and locality. I restricted var. *pumila* to the shores of the Great Lakes. I have seen, however, a series of specimens inhabiting the sandy soil of prairies, dunes, and bluffs along the Mississippi River (Newport, MN; Pepin, WI; Wabasha, MN; New Albin, IA, and Fulton, IL) with leaves much more like those of var. *pumila* than typical var. *besseyi*. The leaves are narrowly elliptic to oblanceolate with acute apices and long-tapering bases, and their leaf blade l/w ratios are at least 3.5:1 (average = 3.84:1). The twigs are completely glabrous. Specimens with similar leaves were found elsewhere scattered within the range of var. *besseyi* (Map 1; stars).

ACKNOWLEDGMENTS

Hugh Iltis encouraged me to take a second look at Wisconsin's sand cherries. Paul Catling and Tony Reznicek willingly discussed their knowledge of sand cherries with me via email. Curators of the following herbaria were gracious in loaning specimens: APCR, ARIZ, DUKE, IA, ILLS, IND, MICH, MIN, MO, NCU, OSH, POM, RSA, UARK, UC, UWEC, UWSP, WIS, and WMU. Undergraduate students at UWEC that helped with specimen curation as well as data acquisition and management include Christa Eastvold, Kelly Leinberger, Sabrina Hanson, and Amy Welbourn.

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LEAF FORMS IN SASSAFRAS IN SOUTHEASTERN MICHIGAN

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[Editor's Note: This paper dates from 1996. It was found among Professor Wagner's effects by Florence Wagner; the file included detailed reviewer's comments and a provisional acceptance by the then-editor. The typescript also had pencilled notations in the author's hand. Richard K. Rabeler and Anton Reznicek, both of the University of Michigan Herbarium, North University Building, Ann Arbor, MI, 48109, requested that the present editor incorporate the reviewers' comments and Herb's emendations into a corrected and updated version; what follows is, I hope, faithful to the author's intent.]

Sassafras (*Sassafras albidum* (Nutt.) Nees, Lauraceae) is a common woody plant that ranges from Maine to Michigan and south to northern Florida and Texas. A similar species (*Sassafras tzumu* Hemsley) occurs in mainland China, and a third species, *Sassafras randaiensis* (Hayata) Nakai, is endemic to Taiwan. In the Great Lakes region, *S. albidum* is unknown north of Chicago (a population from Kenosha County, Wisconsin, just over the Illinois border, was long ago extirpated). The species is otherwise unknown for Wisconsin and Minnesota. It is common in lower Michigan north to Benzie County.

In the open, it forms compact clones of small trees, because new stems are readily formed from root sprouts, but under a forest canopy it develops as solitary or well-separated tall trees; it may attain a height of 40–50′ in Michigan (Smith 1997), and further south to 80′ (Taber 1937). Sassafras tea, made from the steeped, reddish roots, is a popular item among wild food buffs. A search of the worldwide web using the keyword "sassafras" will reveal a great many sites devoted to the food values of the plant. The aromatic sassafras leaves, together with those of the other Michigan member of the Lauraceae, the spicebush (*Lindera benzoin* (L.) Blume) are important (but not exclusive) foods for the larvae of Spicebush Swallowtail (*Papilio troilus* L.) and the giant silkworm moth, Promethea (*Callosamia promethea* Drury) (Tyler 1975 and Ferguson 1972, respectively).

Platt (1953) pointed out that "Sassafras is famous for its three types of leaves on the same branch." These leaf forms are often referred to as entire (i.e., without lobes); mitten-shaped (with one large lobe and one small, lateral lobe); or three-lobed (with one central and two lateral lobes (Barnes & Wagner 1981). Voss (1985) commented, "Some leaves have a characteristic 'mitten' shape with one lobe as a 'thumb,' others have two 'thumbs,' and others are unlobed; all three shapes occur on the same plant, often even on the same branch."

FIGURE 1. Sassafras leaves of minimal lobation (blade Types 1 and 2). Note angle of the sides of the lower part of the blade (see also Fig. 3).

Some authors mention that sassafras may have 4- or 5-parted leaves (those who do include Ilick 1927, Taber 1937, Gleason & Cronquist 1991, Barnes & Wagner 1981, and Harlow et al. 1991).

For simplicity and consistency, I simply classify the blade types according to the number of tips, as shown in the figures. Figure 1 at the top shows blades entire or unlobed, which I score as a "Type 1." Figure 1 at the bottom shows blades with one lateral segment plus one central segment, making two segments altogether; these are scored as "Type 2." Figure 2 at the top shows blades with one central segment and two laterals, giving three altogether; these are scored as "Type 3." Figure 2 shows at the bottom leaves with four segments, scored as "Type 4." Figure 3 shows "Type 5" at the top, with five segments, and at the bottom "Type 6," with six segments.

We studied these different types in southeastern Michigan clones. Two clones

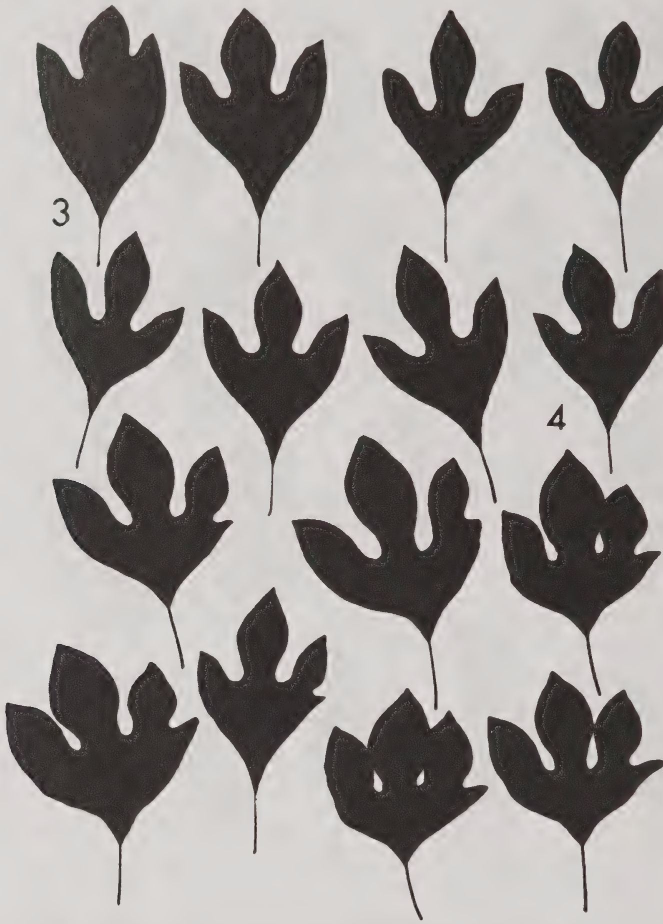

FIGURE 2. Sassafras leaves of intermediate lobation (blade Types 3 and 4).

were studied in detail, these occurring side-by-side north of M-36, west of Hamburg, in section 16, Hamburg Township, Livingston County. The study began in 1982; on a later visit to the site, my assistants and I found that the clones had been destroyed, as the area is under development.

To study the sequence of increasing complexity of segmentation, the leaves from a given clone can be arranged in a morphological sequence from base to tip of the year's twig, starting with Type 1. As more segments appear in the series, the central segment always remains the largest, and the lateral segments become progressively smaller in relation to the central segment, as the number of laterals increases, until we reach Type 6, with very small ultimate laterals (Fig. 3). This is well illustrated in the mitten form, in which one segment, the morphologically central segment, is always larger than the other, the "thumb" (Fig. 1).

FIGURE 3. Sassafras leaves of maximal lobation (blade Types 5 and 6). Note angle of the sides of the lower part of the blade (see also Fig. 1).

In some of the Type 3 and in the central three segments of Types 4 and 5, the lengths may be nearly equal, but there is always at least a slightly greater development of the middle segment.

Maximum sinus formation in Types 2 and 3 generally reaches less than half of the total blade length, but in Types 4, 5, and 6, it is commonly more than half, and the sides of the sinuses become more concave. Concomitant with increasing segmentation, the angle of the blade base increases from 50–70° to nearly 100° (compare Figs. 1 and 3). Leaf Type 3 is intermediate.

Although there are clearly six types of leaves (perhaps more, although we have not yet found forms with seven or eight segments), intermediates do occur, as can be demonstrated in a long series of specimens. For example, the silhouette immediately after number 2 in Fig. 1 actually marks an intermediate between Types 1 and 2. Likewise, the specimen following number 4 in Fig. 2 marks the transition between Types 3 and 4. The beginnings of the next-following stages are thus represented by small marginal segments, only a fraction as

large as the laterals in that position, and often merely little projections at the edge of the blade.

To illustrate the differences between individual whole branches and the locations of the leaves on the year's shoots, we took the lateral branches from each of two clones growing side-by-side at our Livingston County site. They represented the most extreme types that we encountered, and they were growing under altogether similar site conditions, so that the differences would presumably be genetically controlled. Of one clone (labelled "Clone A") almost all the branches showed at least one Type 4 or Type 5 leaf. Branches lacking either or both of these were infrequent. Of the other clone (labelled "Clone B") the branches had very few segmented leaf types. Almost all the leaves on Clone B were of Type 1—leaves entire and unlobed. In the following chart, the leaf types are arranged strictly in order of their position along 18 branches per clone, from the base (at left) to the top (at right):

Clone A with many lobed leaves	Clone B with mainly unlobed leaves
3 3 5 5 3 3	1 1 1 2 2 2 1
1 1 2 3 4 4 3	1 1 1 1 1 1 1
1 1 2 3 3 4 3	1 1 1 1 1 1 1
3 3 3 5 3 3 3 3	1 1 1 1 1 1 1
1 1 2 3 5 3 5 3	1 1 1 1 1 1 1 1
1 3 3 5 3 3 3 3	1 1 1 1 1 1 1 1 2
1 3 3 5 4 3 3 3 3	1 1 1 1 1 1 1 1 1
1 1 2 4 3 3 3 3 3	1 1 1 1 1 1 1 1 2
1 1 3 3 3 3 3 3 4 3	1 1 1 1 1 1 1 1 3
1 1 1 1 2 3 4 3 3	1 1 1 1 1 1 1 2 1 1
1 1 1 3 3 3 4 4 3	1 1 1 1 1 1 1 1 1 1
3 3 1 3 4 3 3 3 3	1 1 1 1 1 1 3 1 1 1
1 3 1 3 4 5 3 3 3 3	1 1 1 1 1 1 1 1 1 2
1 1 2 3 3 4 3 3 3 2	1 1 1 1 1 1 1 1 3 2 1
1 2 1 3 3 5 3 3 3 3 3	1 1 1 1 1 1 1 1 1 1 1
1 2 3 3 3 3 4 3 5 4 3 3	1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 3 3 4 5 3 3 3 3	1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 3 3 4 4 3 3 3 3 3	1 1 1 1 1 1 1 1 1 3 1 1

The average lateral branch has nine leaves, with a range from six to thirteen. The central or leader branches are generally the larger ones and have more leaves. Because of the great variability, as illustrated here, and because of the changes in incidence of the different leaf types from the lower branches to the crown (discussed below), statistics for their occurrence were not calculated. However, rough estimates in the field involving all ages and sizes of clones indicate that Type 1, the simple, entire-bladed form, comprises at least three-fourths of the total leaf population, and Types 2 and 3 together make up practically all the rest. Leaf Types 4, 5, and 6 are rare, comprising less than one percent. Type 6 is very sporadic, and we have seen only a few examples. Whole clones like Clone A with numerous Types 4, 5, and 6 are rare. Where there are

Types 2 and 3 and higher-level blades, the Type 1 leaves are commonly found as the first-formed leaves of the season, i.e., the lowest ones on the twig, as shown in Clone A above; the morphogenetic transition between Types 1 and 3 is usually abrupt, however, so that there are far fewer Type 2 leaves than either of the others. Overall, there are less than one-tenth as many Type 2 leaves as Type 3 leaves. The transitions between 3 and 5 are common. Indeed, there were over half again as many Type 4 leaves as Type 5 leaves.

In any one clone, the leaves on average appear to become progressively more unlobed the higher on the plant they are produced. Thus a clone with a substantial incidence of Type 3 on the branches below four meters may have only a few Type 3 on branches above 5 meters. Most of the Types 2 and 3 (as well as 4 and 5) are on lower branches and leader shoots, and on suckers.

To gain some picture of the differing positions of leaf types in different clones, we surveyed by car an area including adjacent parts of Lyndon Township, Washtenaw County; Waterloo Township, Jackson County; and Unadilla township, Livingston County. An arbitrary limit of 100 clones of all sizes was examined. We classified them according to the blade types of the crowns. Those with almost exclusively Type 1 leaves were made one category, those with one-third or more Type 3 a second category, and those that did not fit either were put in an intermediate category. The intermediate category comprised 24 percent of the clones we sampled. Of the remaining clones, 47 percent had mainly Type 1 leaves, and 29 percent had numerous (one-third or more) more lobed leaves. The Type 3 leaves were mostly from older plants. Four of these older plants had Types 4 and 5 blade forms on the lower shoots; in two of them, these blade forms were rare, in one frequent, and in one common. This last was a clone of low stature, the ramets only up to 3 m tall. Thus, even though in the total leaf population of all sassafras plants, the Types 4 and 5 probably constitute less than one percent, of whole clones as many as four percent may have some of these more divided leaf types, but it may take careful searching to find them. If one limits the scoring of clones to large-sized ramets five or more meters tall, the fraction of mainly simple leaves becomes larger, but that too varies from clone to clone.

Sassafras leaves thus show a considerable instability, varying as they do from no lobes at all to several lobes. The primitive condition is surely shown by the unlobed form, which is typically the state prevalent in the Lauraceae, as well as its related families, such as Magnoliaceae, Illiciaceae, Annonaceae, Aristolochiaceae, and Piperaceae. Leaf lobation in sassafras is a fine example of a derived character or apomorphy that is only variably expressed. Beyond a purely morphological description, it is intriguing to consider whether the lobation of these leaves is adaptive. With present information, however, it appears that the lobed condition is an evolutionarily neutral character state.

Our survey of *Sassafras* clones in southeastern Michigan leads to the following conclusions: (1) Relative incidence of the various leaf forms differs from clone to clone. (2) The presumably primitive state of non-lobed leaves is most common, with a few extreme exceptions such as Clone A described here. (3) The order of relative abundance of these leaf types, common to rare, is approximately 1 – 3 – 2 – 4 – 5 – 6, with a quick drop-off between 2 and 4. (4) Correlated with

the change from unlobed through 6-lobed is a strong widening of the angle between the two sides of the lower one-third to one-half of the blade.

It should be interesting to determine whether character states similar to those described here for southeastern Michigan occur as well in other parts of the wide range of sassafras.

For their aid in studying these populations, I acknowledge with thanks William Brodowich, Robert Masta, and Steven Kobylarz.

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REVIEW

Emanuel D. Rudolph's STUDIES IN THE HISTORY OF NORTH AMERICAN BOTANY, with an appendix on the relationship between science and religion. Ronald L. Stuckey and William R. Burk, editors. September, 2000. Sida Botanical Miscellany No. 19. (ISSN 0883-1475, paperback; ISBN 1-889878-05-7, paperback.) xxx + 376 pp. $45 (+$3.71 for Texas residents) + postage $4.50 for first copy, $1.00 for each additional copy to the same address; postage outside the USA $8.00 for first copy, $2.50 for each additional copy to the same address. Check or money order payable to BRIT Press; Visa, MasterCard, or purchase order accepted: BRIT Press, 509 Pecan Street, Fort Worth, Texas 76102, USA.

This is a tribute and memorial to Emanuel D. Rudolph, just "Rudy" to the thousands whose lives he touched during his long tenure in Botany at the Ohio State University. It is richly illustrated with over 200 b/w and colored photographs. The color cover features hollyhocks, to honor Rudy's observation that their introduction from Europe serves "to remind us of man's attempt to preserve the familiarity of his surroundings."

The editors have gone through Rudy's files and archives and extracted thirty papers, presented here in eight parts: 1) Botany in Textbooks, 2) Botany in Children's Books, 3) Botanical Teaching in Classrooms and Laboratories, 4) Botanical Educators, 5) Botanical Illustration, 6) Women in the Development of American Botany, 7) Writing the Missouri Botanical Garden History, and 8) Writings on Selected Topics in American Botanical History.

I know of no parallel to this book. Certainly, in literature and music there are ample precedents for publishing incomplete works posthumously, but scholarly work generally requires the hand of the author himself or herself to make it complete. Nonetheless, the editors undertook to bring these papers to light. Emanuel D. Rudolph (1927–1992) left us too soon, and his editors have filled in the lacuna.

Given the nature of the material, the book cannot be read as a continuous narrative or disquisition. Necessarily, it jumps from one thing to another, even with the best efforts of the editors to fill in details and provide a context. I think readers will enjoy this: it is a sampling of the range of the man's mind and interests, and one can jump in at almost any point and benefit from Rudy's spare prose and (often) wry insights. The editors are to be congratulated for carefully labelling the original nature of each contribution—whether it was intended as a presentation at a scientific meeting, a paper someday to be submitted for publication, or whatever.

The editor of *Sida Miscellany*, Barney Lipscomb, deserves special mention and thanks for having perceived the value of this sort of work, and he doubtless spent many an hour with the editors in seeing this unusual synthesis into print. It is typographically flawless, and the photographs are faithfully reproduced, liberally captioned, and always given proper attribution.

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NOTEWORTHY COLLECTION

MICHIGAN

PICEA ABIES (Linnaeus) H. Karsten (Pinaceae) Norway Spruce

Previous knowledge. Norway spruce is an introduced evergreen tree native from the Alps, Balkans, and Carpathians north to Scandinavia and Russia. In North America it is widely planted as an ornamental or timber tree in the northeastern United States, southeastern Canada, the Rocky Mountain region, and Pacific Coast states (Little 1979). *Picea abies* was included in the Flora of North America (Taylor 1993) as an established, naturalized species (successfully reproducing and surviving without human intervention). As a former Flora of North America editor, I know that the species was not mapped in that flora because only one specimen representing a naturalized population (from Minnesota, Thieret 1989) was known to the FNA author and Pinaceae editor (Taylor 1993). The species originally was not included in the Michigan Flora (Voss 1973), which included non-native species only if established or naturalized. Two specimens from Alger and Lenawee counties (MICH) support the recent inclusion of *Picea abies* in the Michigan Flora (as a note added in the third printing, in 1992).

Mature trees of this species are frequently seen as ornamentals at homesites, along roadsides, and in plantations. Reproduction in North America is rare in comparison to that of introduced species of *Pinus* that populate open habitats. The root system of Norway spruce is typically shallow, and seedlings are sensitive to drought and overheating (Kostler 1956), which are increased by direct sun. Successful reproduction depends on small canopy gaps caused by road construction, windfalls, or logging of mature stands (Jonsson & Esseen 1990).

Significance. This is the first published report detailing naturalization by *Picea abies* in the Michigan flora, and contributes to what little is known about the species' naturalization in North America. Seedlings and saplings of *Picea abies* were found in partial shade, not in open areas or in the deep shade of the parent trees. At both Genesee County sites (details below), offspring ranged from about 15 cm to 2 m tall; in Lapeer County, the largest offspring were larger.

Diagnostic characters. Picea abies commonly grows to heights between 100 and 200 feet (30–61 m) (Safford 1974). Cones are the largest (10–18 cm long) of any *Picea* species in North America. The silhouette of the tree is distinctive with trunk straight and symmetrical, and secondary branchlets drooping straight down from the main branches (Barnes & Wagner 1981).

MICHIGAN. GENESEE CO.: West of Grand Blanc, just north of Torrey Road overpass on west side of US highway 23, east-facing road-cut, partially shaded by deciduous tree saplings, T6N R6E Sec. 23 SW¼, 7 March 1999, *B. D. Parfitt 6049 & C. A. Wade* (MICH, UMF); Richfield Park, north side of park road less than 0.3 mile east of Irish Road, T8N R8E Sec. 17 near center of section, under tall white pines with most branches removed and in small partially shaded clearcut in middle of plantation of several native and non-native

species of conifers, at least 40 adults with 5 offspring 3 m tall and more than 100 most less than 0.6 m tall, 10 March 1999, *C. A. Wade 1505* (MICH, UMF); Lapeer County, McDowell Road 0.4 miles east of Washburn Road; T8N R9E sec 31 NE¼ of NW¼, along 0.1 mile of south side of road, only a few on sunnier north side, north-facing slope of roadcut, northeast of mature Norway spruces that were probably planted, more than 400 offspring ranging from 10 cm to 3 m tall in natural placement (clearly not planted), *B. D. Parfitt 6181 & Charles A. Wade*, 27 April 2000 (UMF, MICH); East of Goodrich: west side of Tody Road just north of Fox Lake Road; T6E R9E sec 30 SE¼ SE¼, east-facing side (mostly northeast-facing) of small, mature Norway spruce plantation in deciduous forest; a few spruce individuals about 20–40 m tall, 100 m or more north and south of the plantation along shady road, 28 April 2000, *B. D. Parfitt 6183* (UMF, MICH).

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CONTENTS

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On the cover: *Birch woodland (Betula papyrifera Marshall), a common feature of northern landscapes. Many of the birches have reached the end of their lifespan, and the site is undergoing succession to balsam fir (Abies balsamea (L.) Miller). Location and photographer unknown.*